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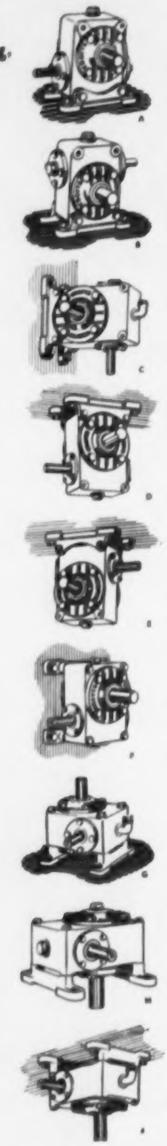
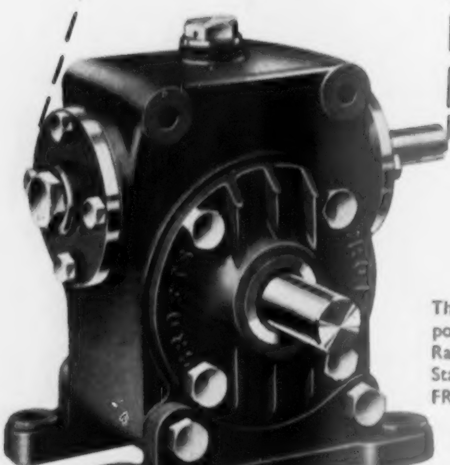
Drive through Crofts Universal Mounting Worm Gear, 1¾ Centres and Flexible Coupling, to Cone Grinding Mill for paint and ink trade.

ALTERNATIVE FOOT MOUNTING POSITIONS



Crofts



"Radiation" UNIVERSAL MOUNTING WORM REDUCTION GEARS COMPLETE THE PICTURE

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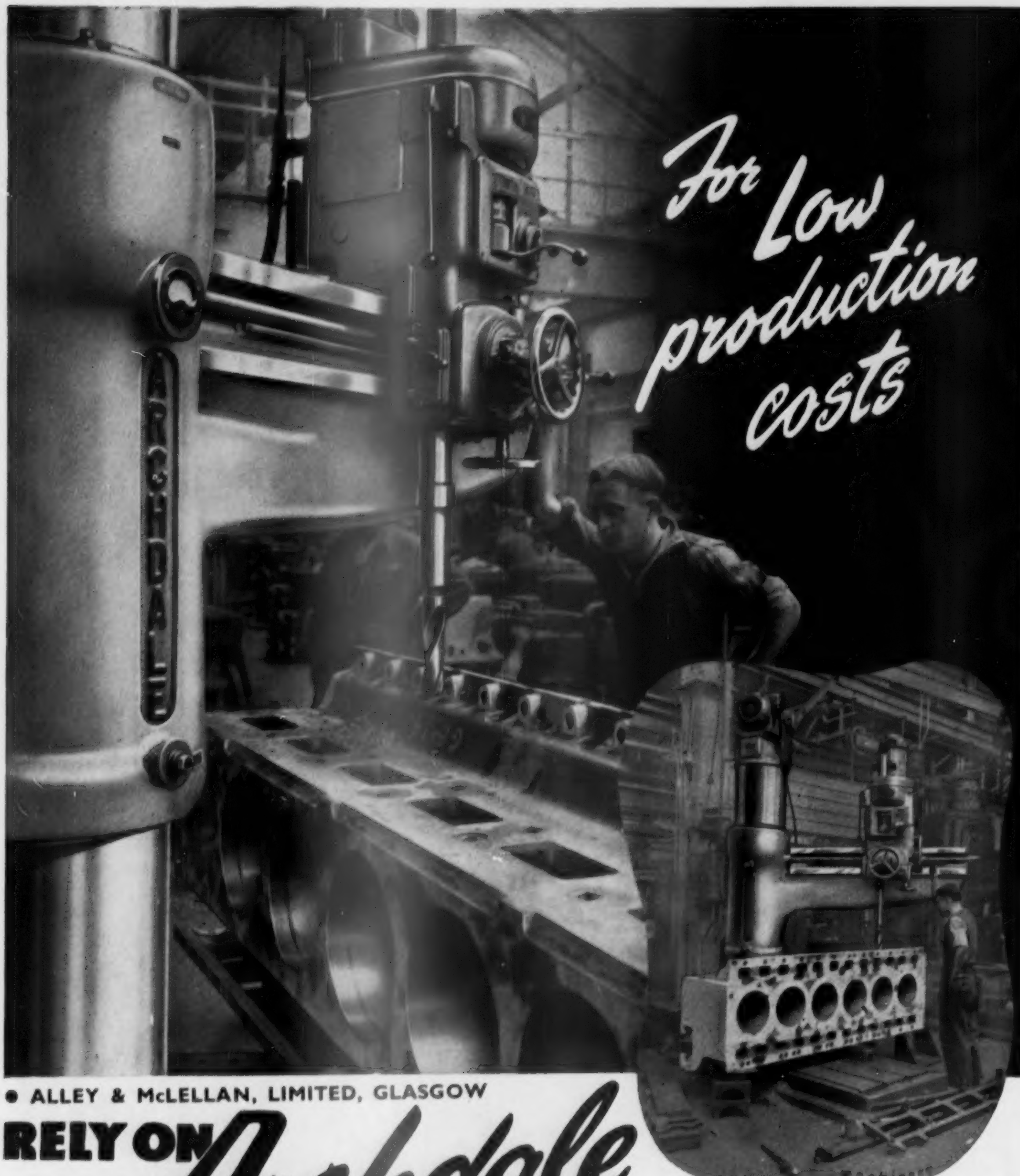
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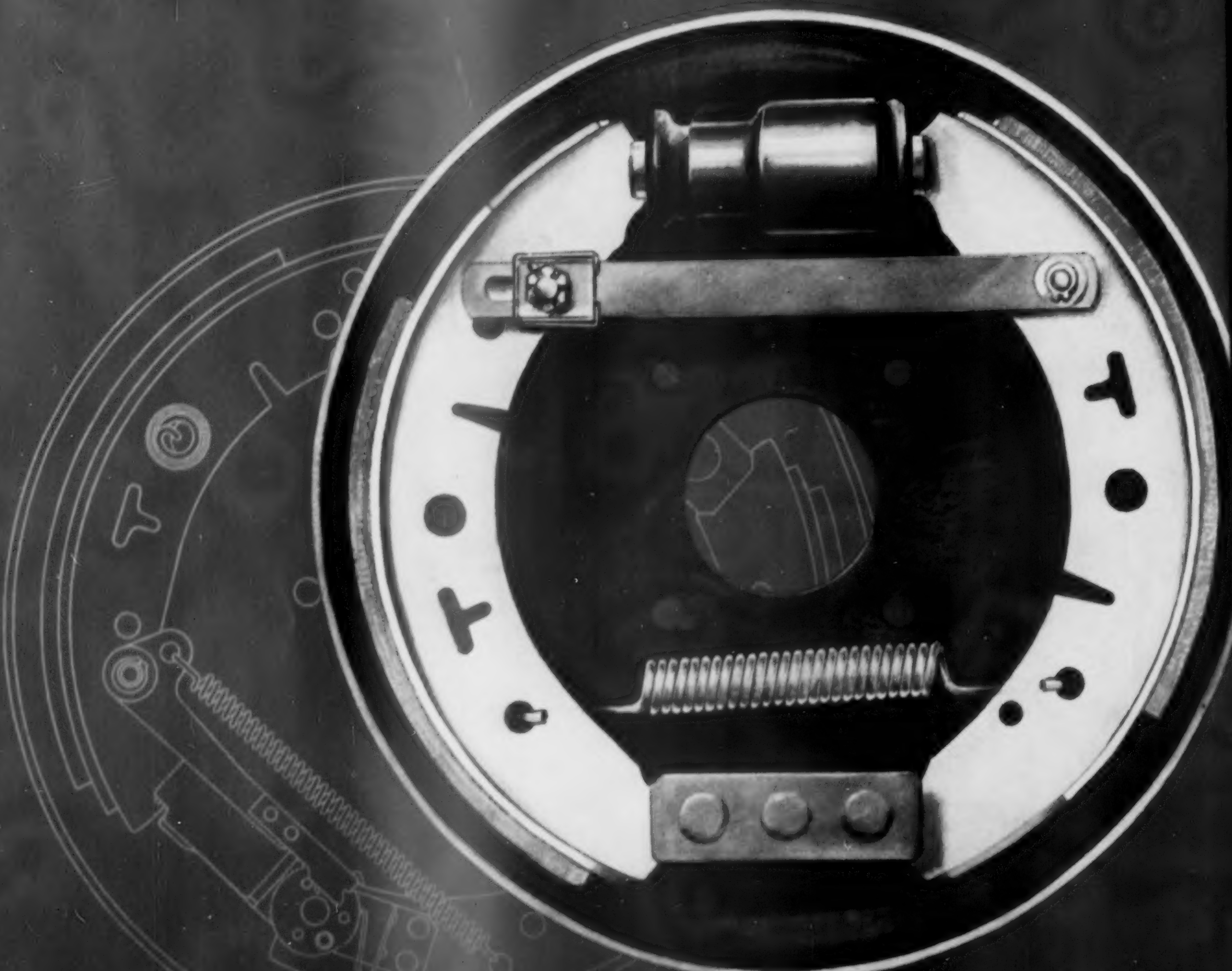

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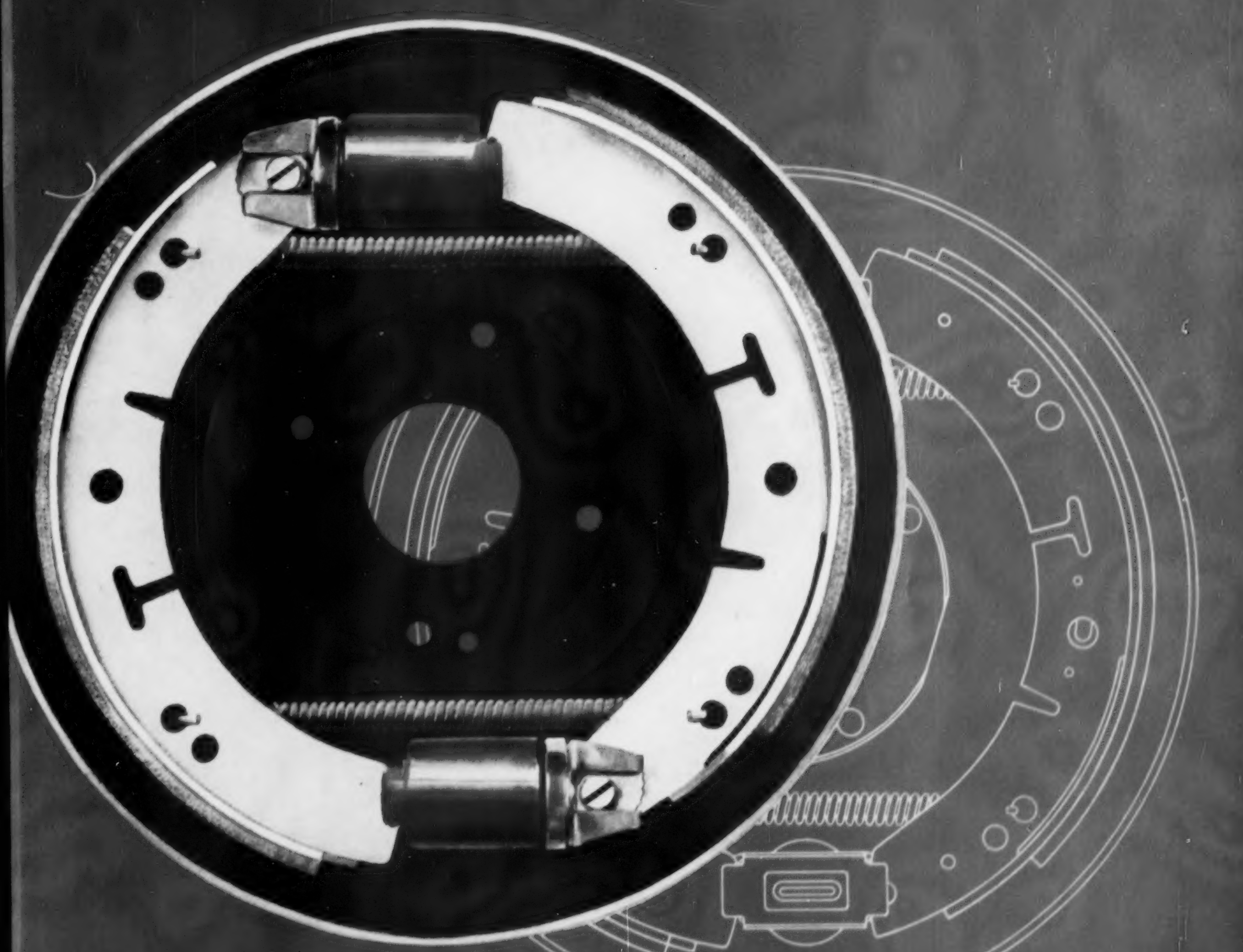
AUTOMOTIVE PRODUCTS COMPANY LIMITED

Lock

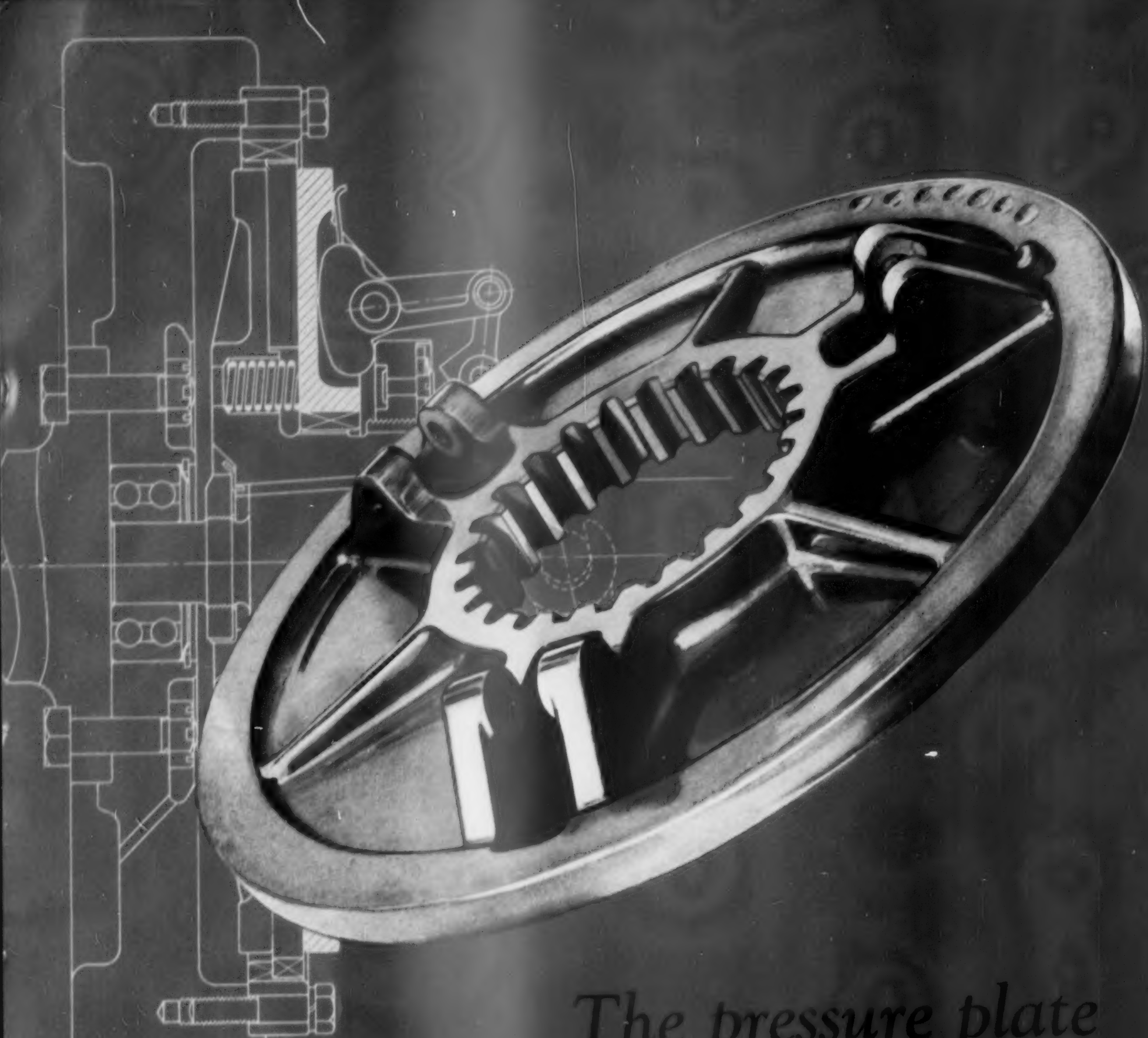
BRAKE SYSTEMS



TWO-LEADING SHOE

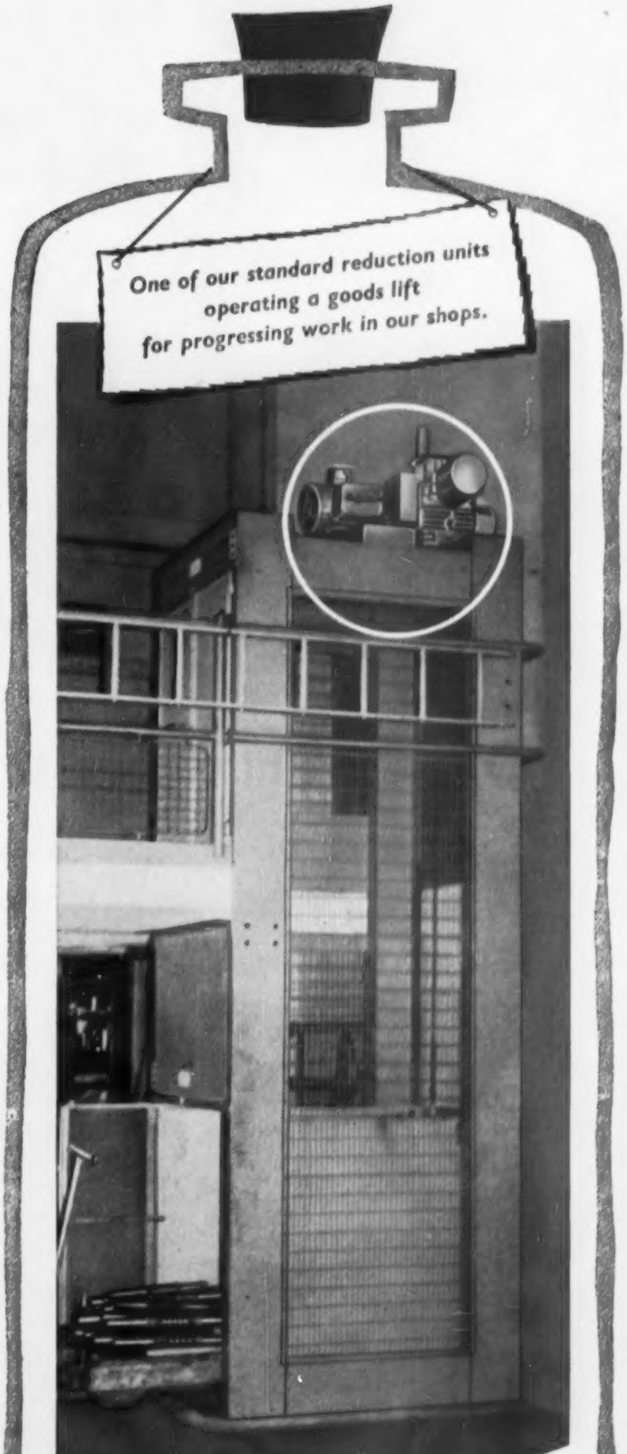
heed

LEAMINGTON SPA, WARWICKSHIRE, ENGLAND



Taking our own medicine

Our own Worm Units are busy at work all over our Milnrow factory. And you'd think someone had given us summat for nowt to see how pleased we are about it. It's partly pride—they're our *own* Worm Units — but mainly because they do the various jobs so very well. They're made to a formula which includes efficiency (a Holroyd Worm and Wheel hold the world record), reliability, and 50 years' experience. This prescription might do *you* a power of good, and it can be . . .



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A Standard Type Holroyd Worm Reduction Unit can be made up from stock, packed, despatched and delivered to you fairly quickly. Worms, wheels, and special units made to order take somewhat longer. For information on Worm Units and applications (and we're discovering new ones every day, like the Goods Lift in the illustration) drop us a line at Milnrow, Lancs. We'll be glad to help you all we can.

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CBC 171


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Wherever aluminium is welded in the Motor Industry the British Oxygen Argonarc process is extensively used. This high-speed welding process makes sound, bright welds, free from porosity—with little or no distortion; eliminates the use of flux—so there are no post-weld corrosion problems and no expensive post-weld cleaning. It produces a joint which is strong and indistinguishable from the parent metal when dressed.
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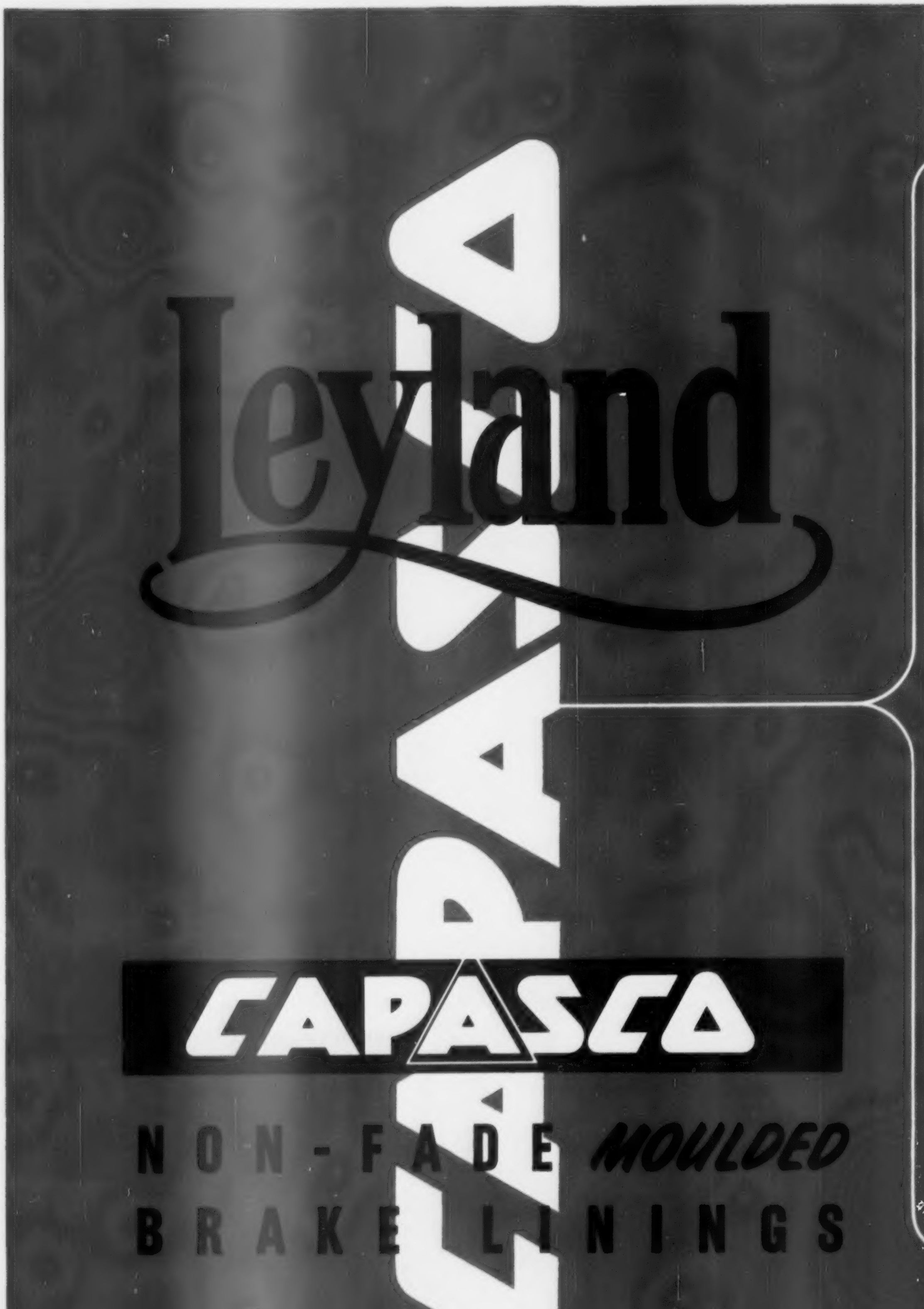
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—miles of engine life, restored by improved performance after reconditioning with Black & Decker equipment. Here's the service you give with these tools: old, badly pitted valves made as new with the Valve Master Refacer, perfect matching of valve and valve seat in a matter of seconds with the Vibro-Centric Valve Seat Grinder. Together these tools form a fast, easily operated unit for continuous maintenance with maximum precision.

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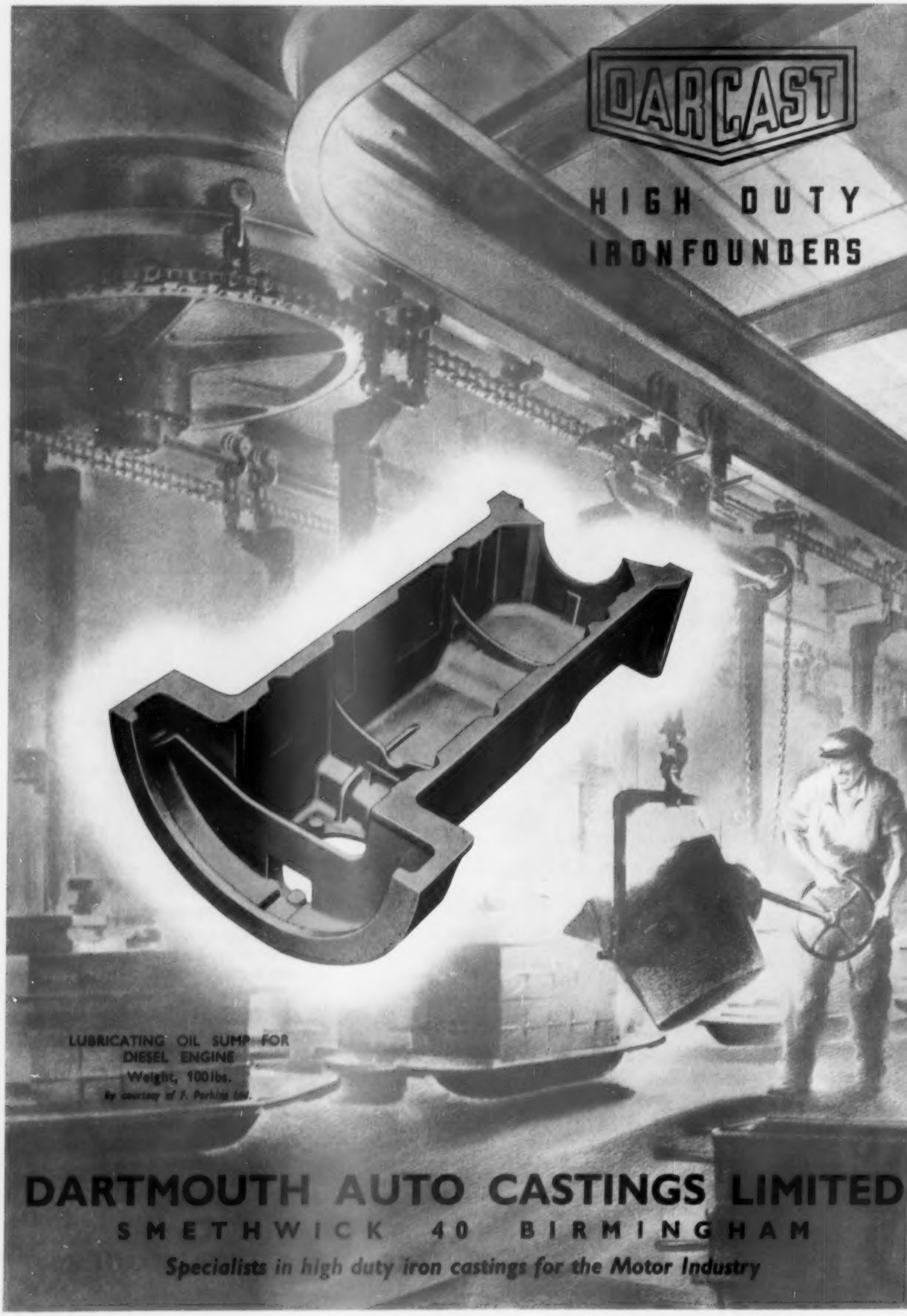
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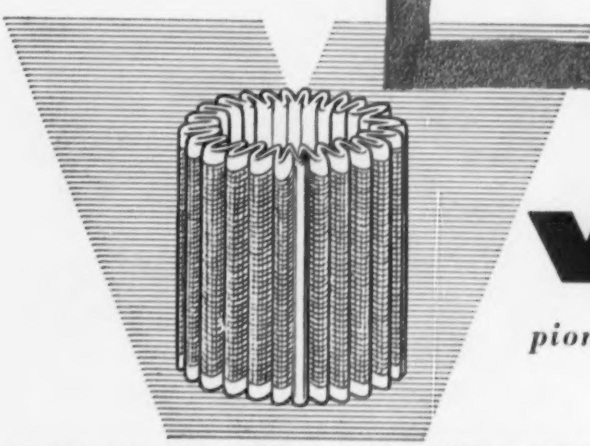

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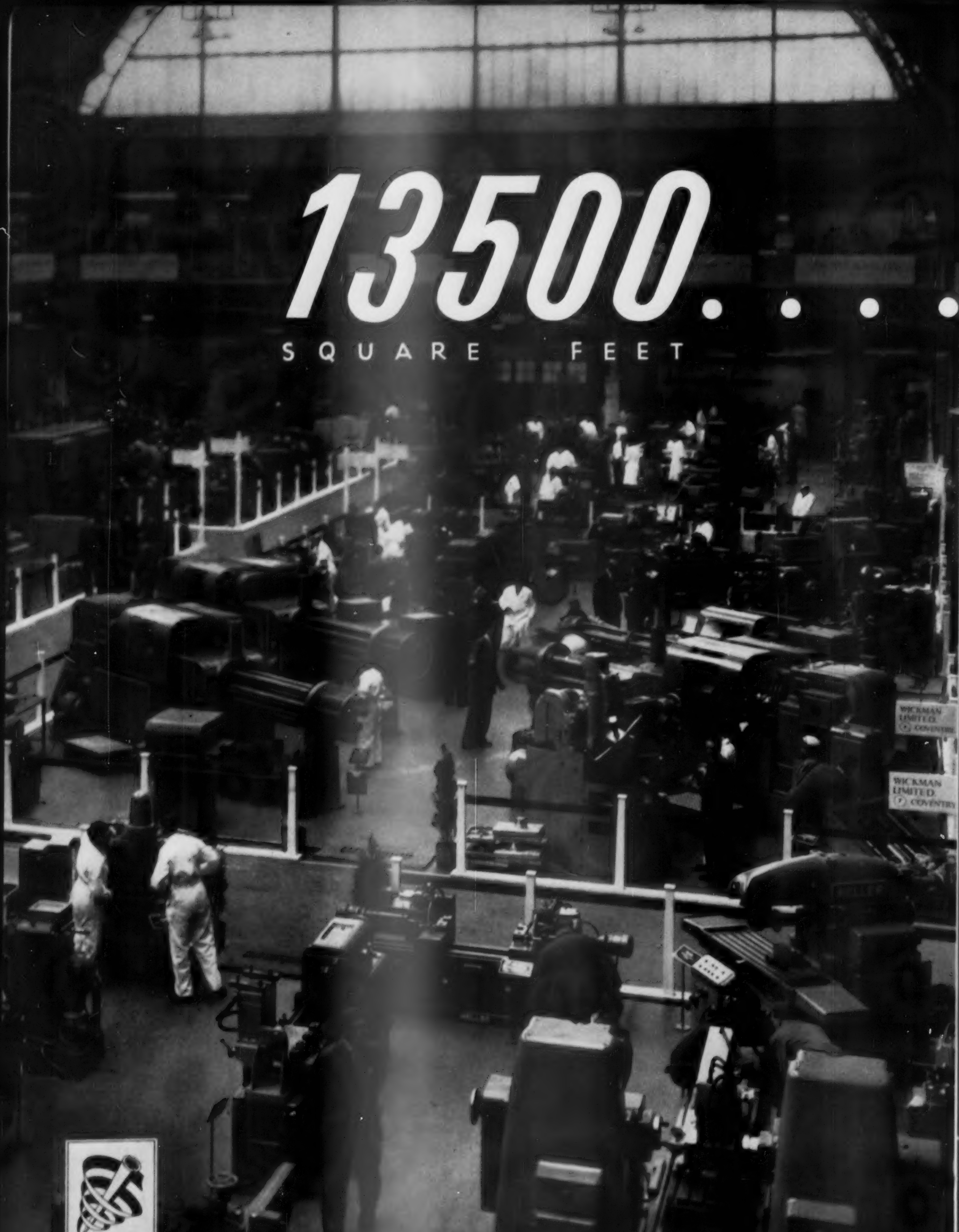
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INTERNATIONAL MACHINE TOOL EXHIBITION 1956
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to display biggest ever

Wickman

exhibit

The Wickman exhibit at this year's International Machine Tool Exhibition will be the largest ever presented by the Company.

Covering 13,500 square feet of stand space and including over one-hundred machine tools in addition to a wide selection of ancillary equipment, the Wickman exhibit will demonstrate the latest techniques in metal-cutting, grinding and honing, forging, and sheet-metal forming.

In tune with to-day's needs, high production is the key dominating the demonstrations which will be a continuous feature of the show, with something to make everyone's visit worthwhile. Be sure to visit us.

WICKMAN LIMITED

MACHINE TOOL DIVISION · BANNER LANE · COVENTRY

Where to go and what to see —

STAND 112
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Wickman Automatics.
Wickman Optical Profile Grinding Machines.
Wickman Erodomatics.

STAND 118
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Pines Tube Benders.
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Weipert Lathes.
Wickman-Moulton Thread Milling Machines.

STAND 119
National Hall

Davenport Multi-spindle Automatics.
Warner & Swasey Chucking Lathes.

STAND 110
National Hall

Losenhausenwerk Balancing and Testing Equipment.

STAND 318
Grand Hall Gallery

Wimet Tungsten Carbide Tools.
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STAND 641
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Also

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STAND 111
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STAND 120
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445W

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GLOUCESTER malleable & grey iron castings

stage of production. The results are smooth skinned castings that need the minimum of machining.

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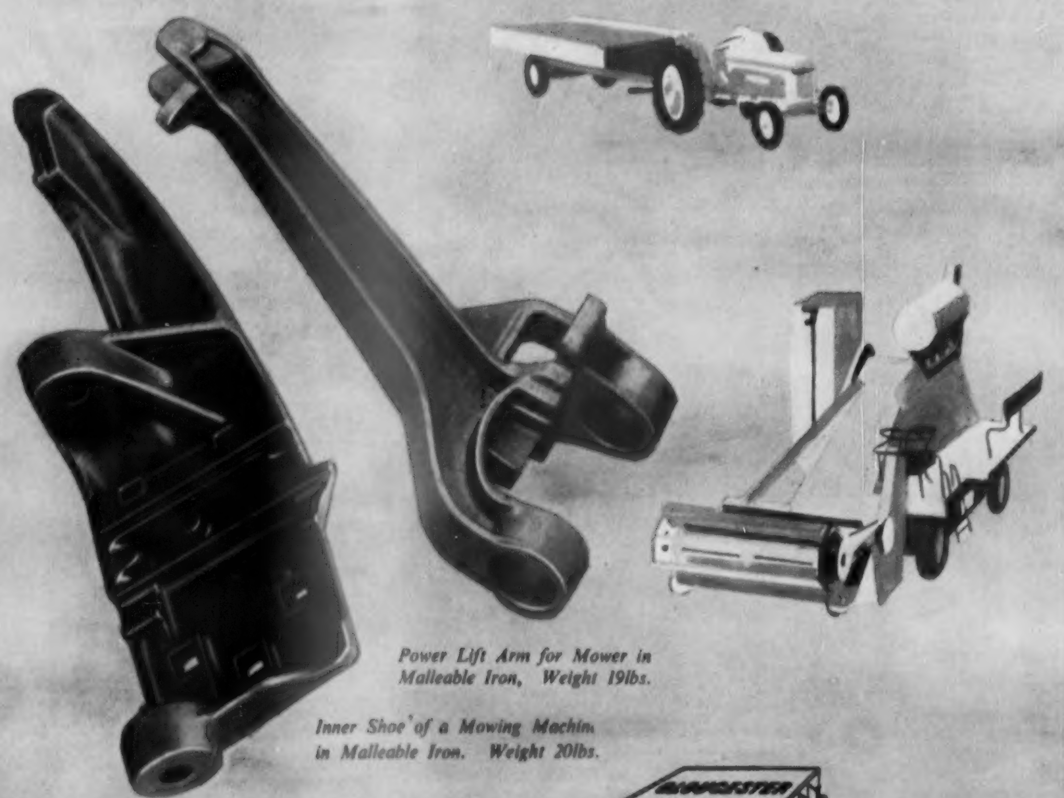
Gloucester Blackheart Malleable	*Gloucester Lamellar Pearlitic Malleable*
Elongation .. 18%	Elongation .. 5%
Yield Point .. 15 tons	Yield Point .. 22 tons
Tensile Strength 25 tons psi	Tensile Strength 35 tons psi



Power Lift Arm for Mower in Malleable Iron, Weight 19lbs.

Inner Shoe of a Mowing Machine in Malleable Iron. Weight 20lbs.

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Here then is a transmission system designed for modern times—a drive shaft that can be installed and almost forgotten.
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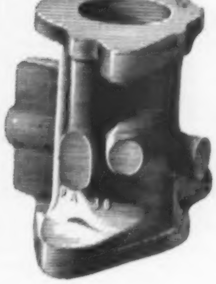
He's just going to use another of those

HARPER CASTINGS



2¼ lb. Carburetter Casting

Rally drivers, and millions of ordinary every day drivers too—are using Harper Castings in their cars—just another example of the ubiquity of these famous castings.

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CASTINGS WITH THE HARPER SKIN

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ALBION WORKS · WILLENHALL · STAFFS

H565

NEW AIR TOOLS HAVE 50% MORE POWER AND NEAR - SILENT OPERATION

Big advance in small power tool design introduced by Consolidated Pneumatic

A number of new tools which will interest production men in all fields of industry have recently been added to the large range manufactured by Consolidated Pneumatic. Their outstanding virtues are lighter weight with greatly increased power. The first is a small Screwdriver Model CP-3008, for which a variety of screwdriving attachments are available. An important feature of this tool is its quiet operation. It has been designed with a supersonic exhaust—a great advantage for production line work where a number of tools are in use. This model is also available as a $\frac{3}{16}''$ and $\frac{1}{4}''$ Drill with lever type throttle.

New high power 'unit type' motor

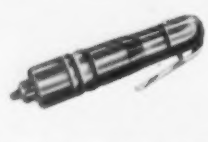
In the new line of drills is Model 3017 for the $\frac{1}{4}''$ to $\frac{5}{16}''$ range, made as a straight model with lever throttle or with a pistol grip handle. These small tools of under 7" length are built with a new high power 'unit type' air motor giving 50% more power than previous models of the same size. This power means highspeed drilling without stalling on break through, and enables deep holes to be drilled in high strength alloys with comparative ease.

Range for capacities of $\frac{3}{8}''$ and $\frac{1}{2}''$

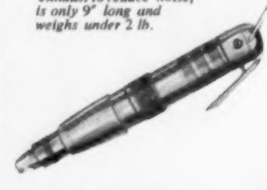
Fcr capacities of $\frac{3}{8}''$ and $\frac{1}{2}''$, Consolidated Pneumatic has introduced the 3075 range of drills with offset handles. These also have the new 'unit type' motor giving 50% more power. They can be supplied with chucks for deep hole woodboring up to 1" diameter.

The introduction of these new lines into the already extensive CP range provides a complete selection of small tools for all classes of work. This includes impact wrenches for nut running operations and a very complete selection of aero riveters. The CP range of grinders, too, are all of the modern steel-clad design. Full details of all these tools are provided in literature freely available on request.

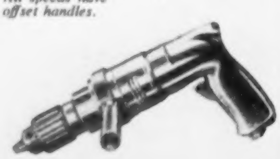
The CP-3008 Drill is made in speeds to suit $\frac{3}{16}''$ and $\frac{1}{4}''$ drilling, is under 7" long and weighs only $1\frac{1}{2}$ lb. Fitted with removable chuck guard.



This CP-3008 Screwdriver has a supersonic exhaust to reduce noise, is only 9" long and weighs under 2 lb.



The CP-3075 Drills are designed for $\frac{3}{8}''$ and $\frac{1}{2}''$ drilling and can also be used for 1" woodboring. All speeds have offset handles.



Four speeds are available in the Model CP-3017 Drill for capacities of $\frac{1}{4}''$ to $\frac{5}{16}''$ all with offset handles, but lever type throttle is optional.

Consolidated Pneumatic

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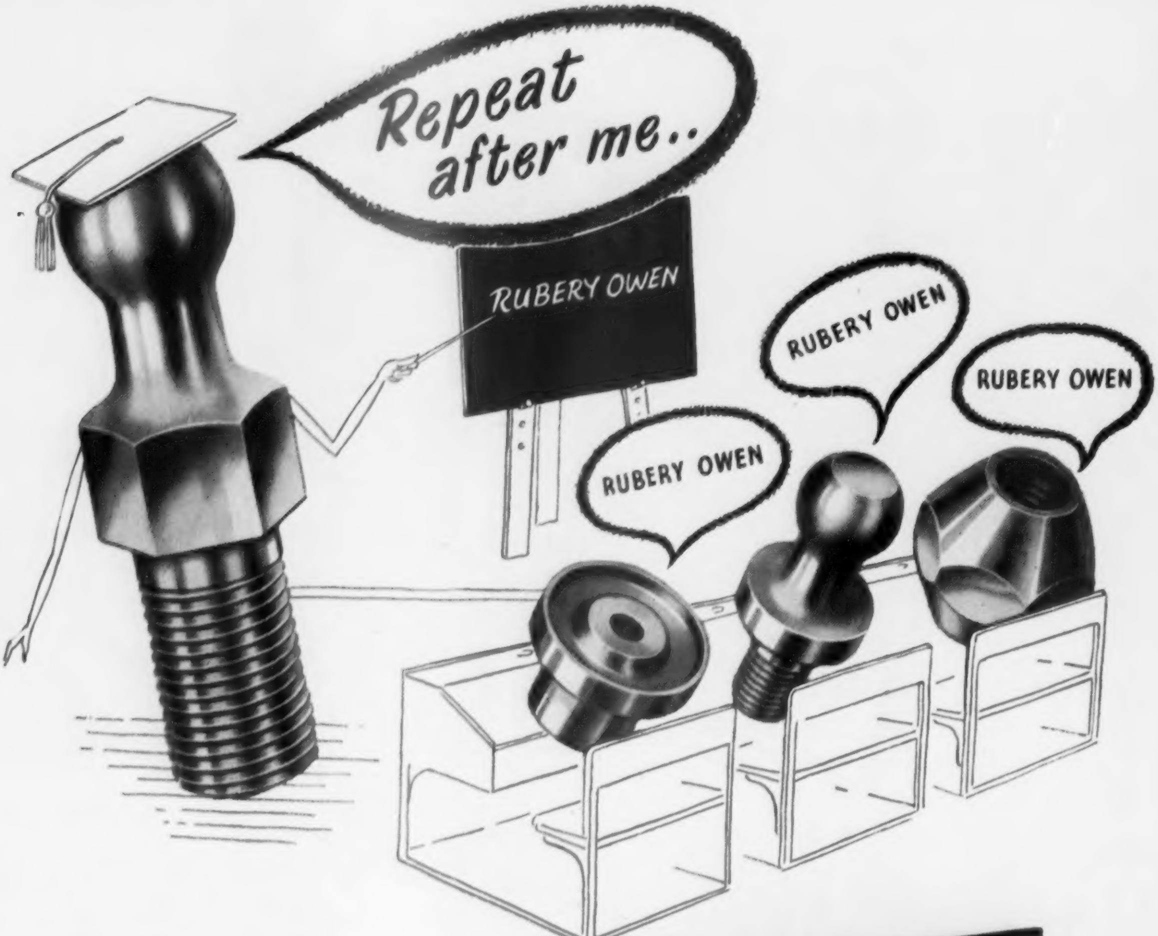
CONSOLIDATED PNEUMATIC TOOL COMPANY LTD., 232 DAWES ROAD, LONDON, S.W.6.

CP 70



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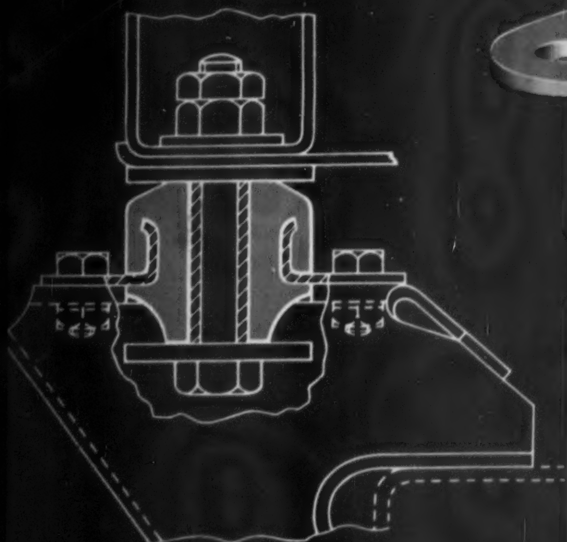
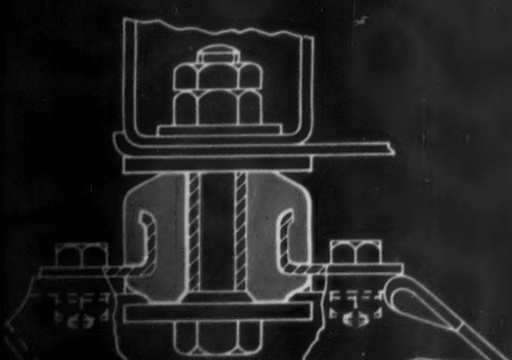
Cab comfort



Extended rebound mounting



Restricted rebound mounting

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CONTROLLED - REBOUND
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As a result of prolonged study of the problem of providing the perfect cab-mounting, we have produced this patented unit which is giving excellent results.

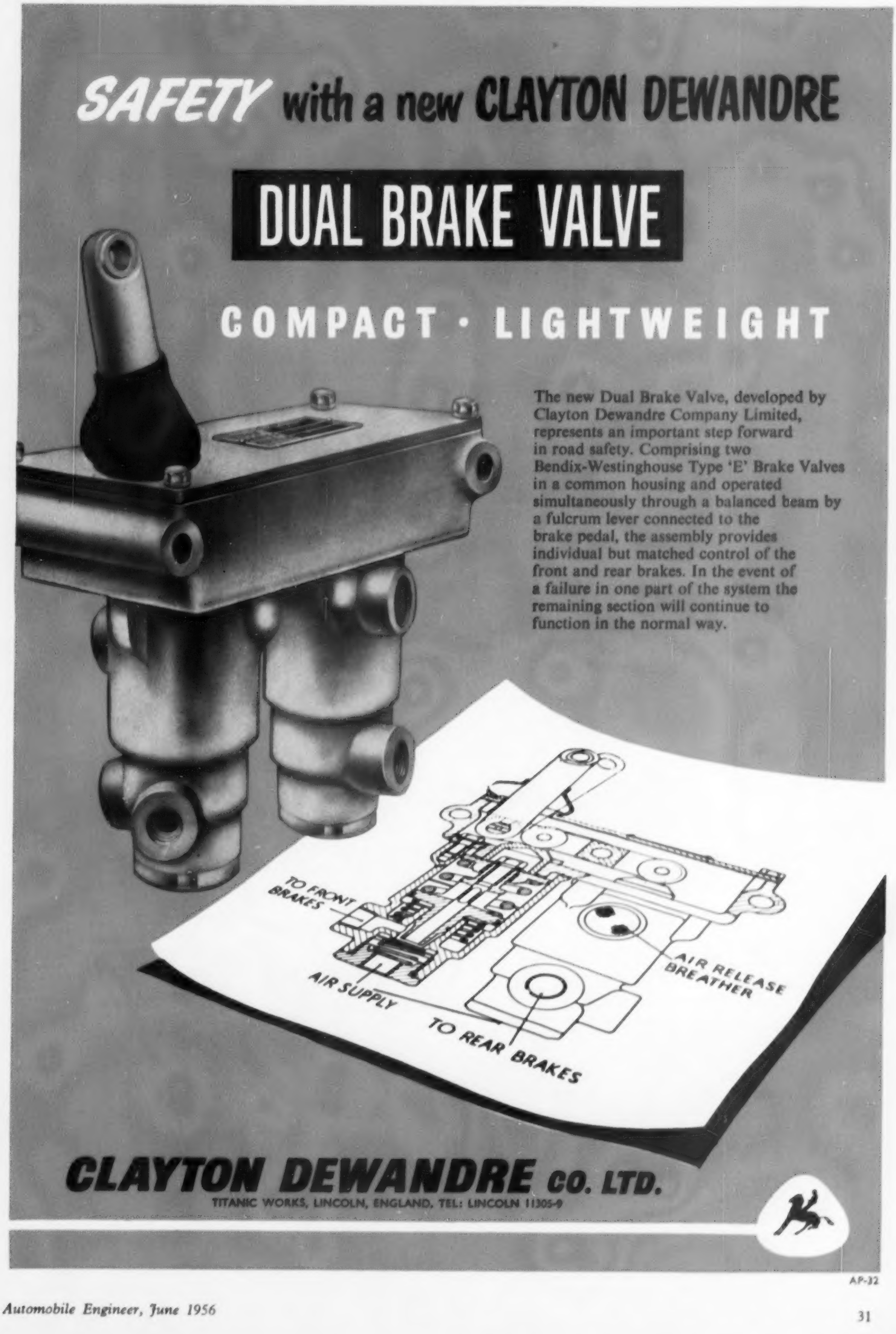
The C.R. (Controlled Rebound) mountings not only eliminate the racking between cab and chassis which took place with rigid attachments, but also do a great deal to improve comfort and insulate the cab against transmitted noise.

The range covers units having various proportions of rebound travel to working travel: in general, one set of mountings have more rebound travel, the other set having restricted rebound for reasons of stability.

These mountings are compact and, of course, embody the characteristic Metalastik rubber-to-metal weld.

METALASTIK

METALASTIK LTD., LEICESTER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The new Dual Brake Valve, developed by Clayton Dewandre Company Limited, represents an important step forward in road safety. Comprising two Bendix-Westinghouse Type 'E' Brake Valves in a common housing and operated simultaneously through a balanced beam by a fulcrum lever connected to the brake pedal, the assembly provides individual but matched control of the front and rear brakes. In the event of a failure in one part of the system the remaining section will continue to function in the normal way.
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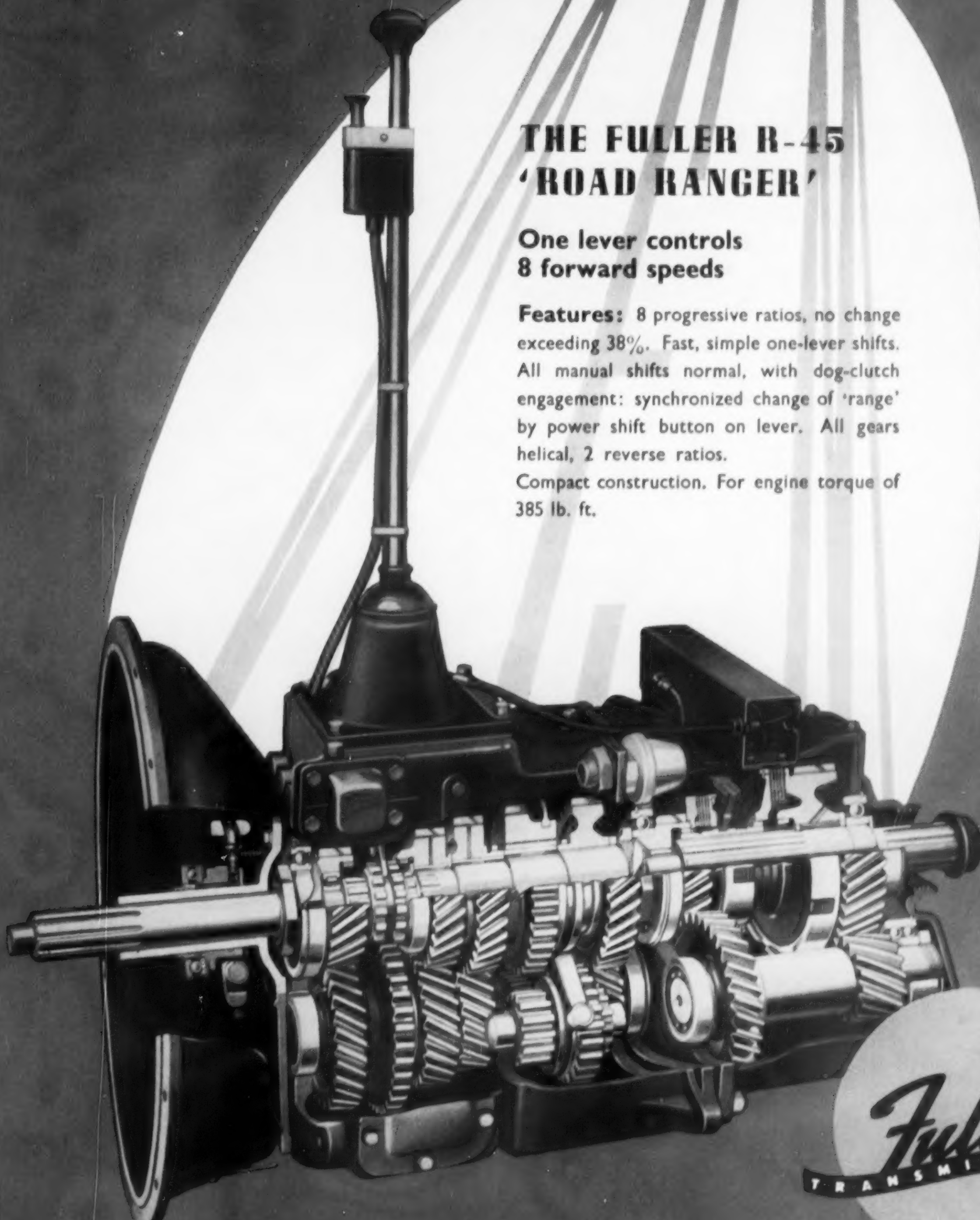

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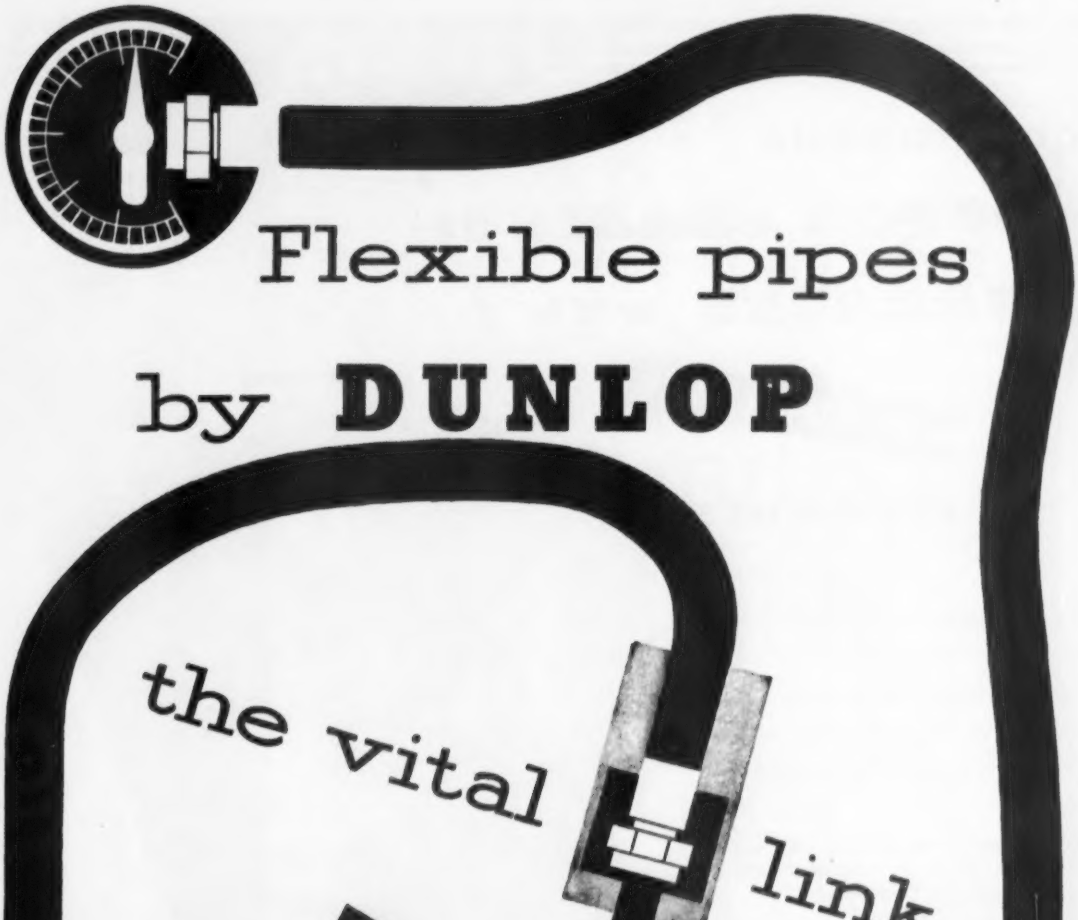
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the vital link

continuous
COPPER BRAZING FURNACES with REMOVABLE elements

Birlec Limited can now offer continuous copper brazing furnaces with removable non-metallic elements as standard equipment. Extensive production trials have taken place and the following advantages proved:—

★ ***Element replacement is easy and can take place, if necessary, while the furnace is in operation.***

★ ***Element replacement does not involve rebricking, and expensive downtime is thus reduced.***

★ ***Element life is no shorter than with conventional nickel-chromium resistors.***

...also INDUCTION HEATING

For brazing a small part to a large article, induction heating equipment is the answer; localised heat means no wasted heat and a "machine tool" approach to equipment design makes the process ideal for quantity-production methods.

Illustration left: A standard 5kW unit, for brazing carbide tool tips; photograph by courtesy of EDIBRAC LTD., Broadheath, Cheshire, manufacturers of Tungsten Carbide products.

Designs are completed for standard 6", 8" and 12" furnaces; may we send details? We should also be pleased to arrange a visit to our Heat Treatment Division, near the main works in Tyburn Road, where test pieces can be brazed in a furnace of this type.

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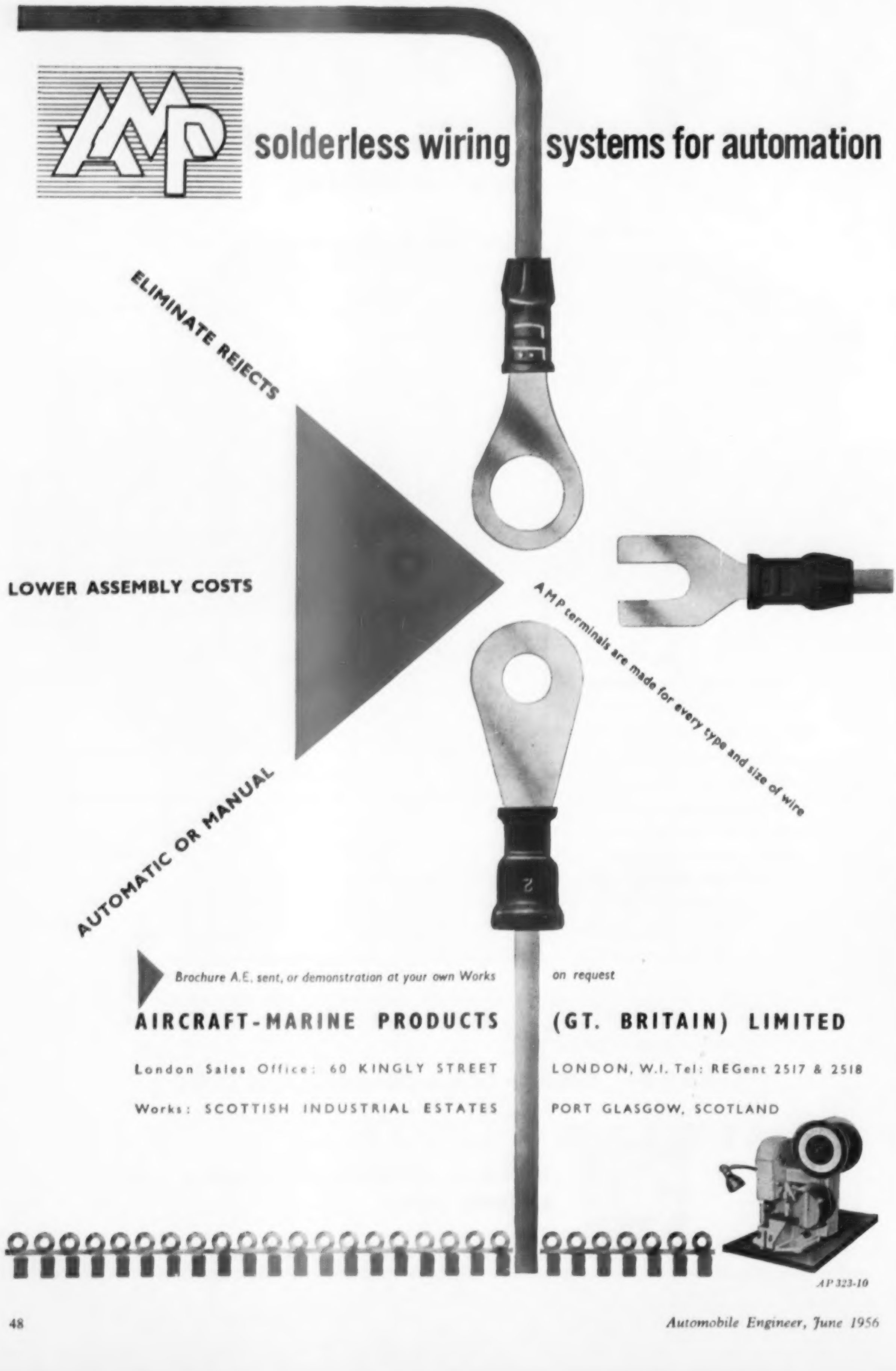
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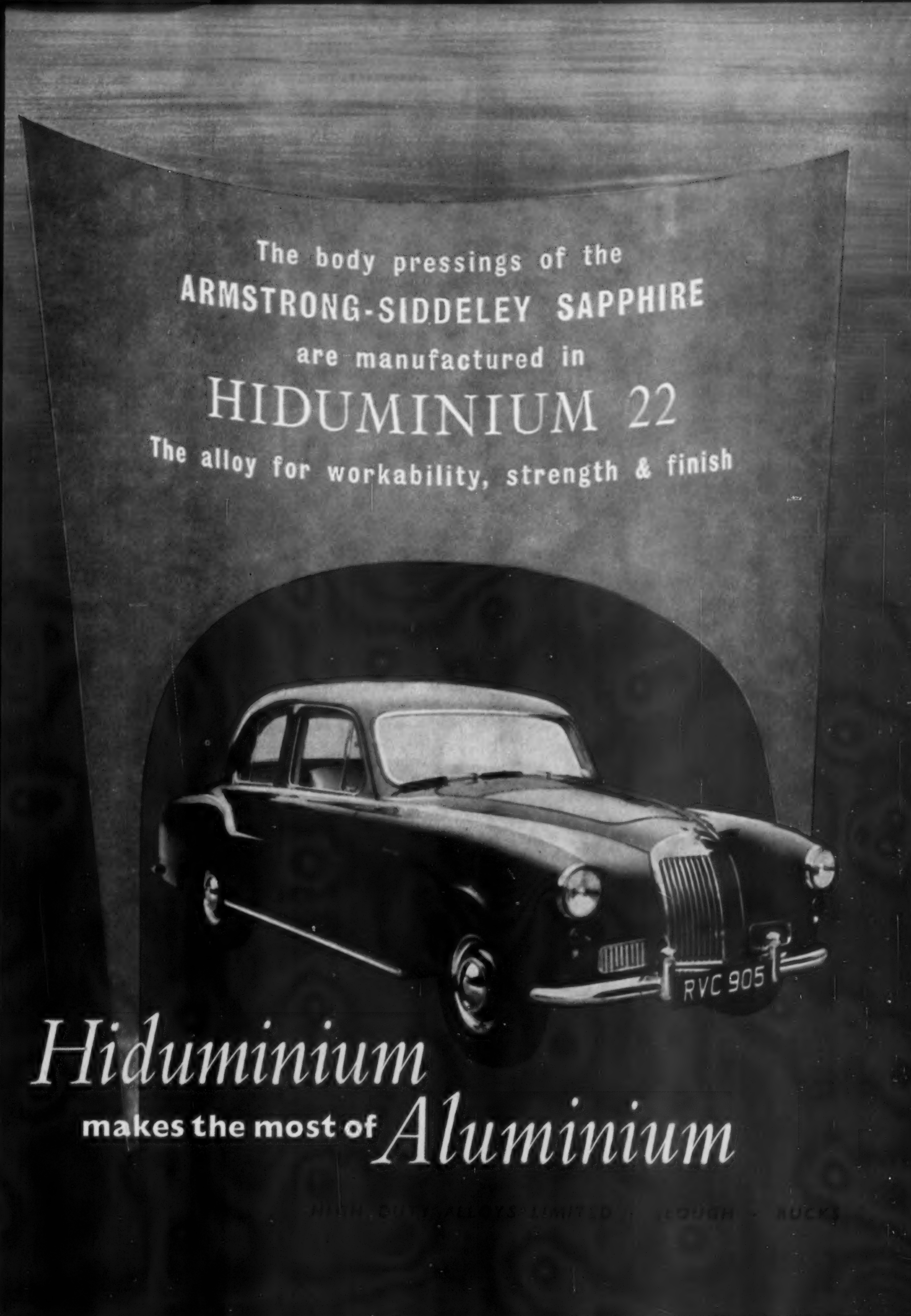

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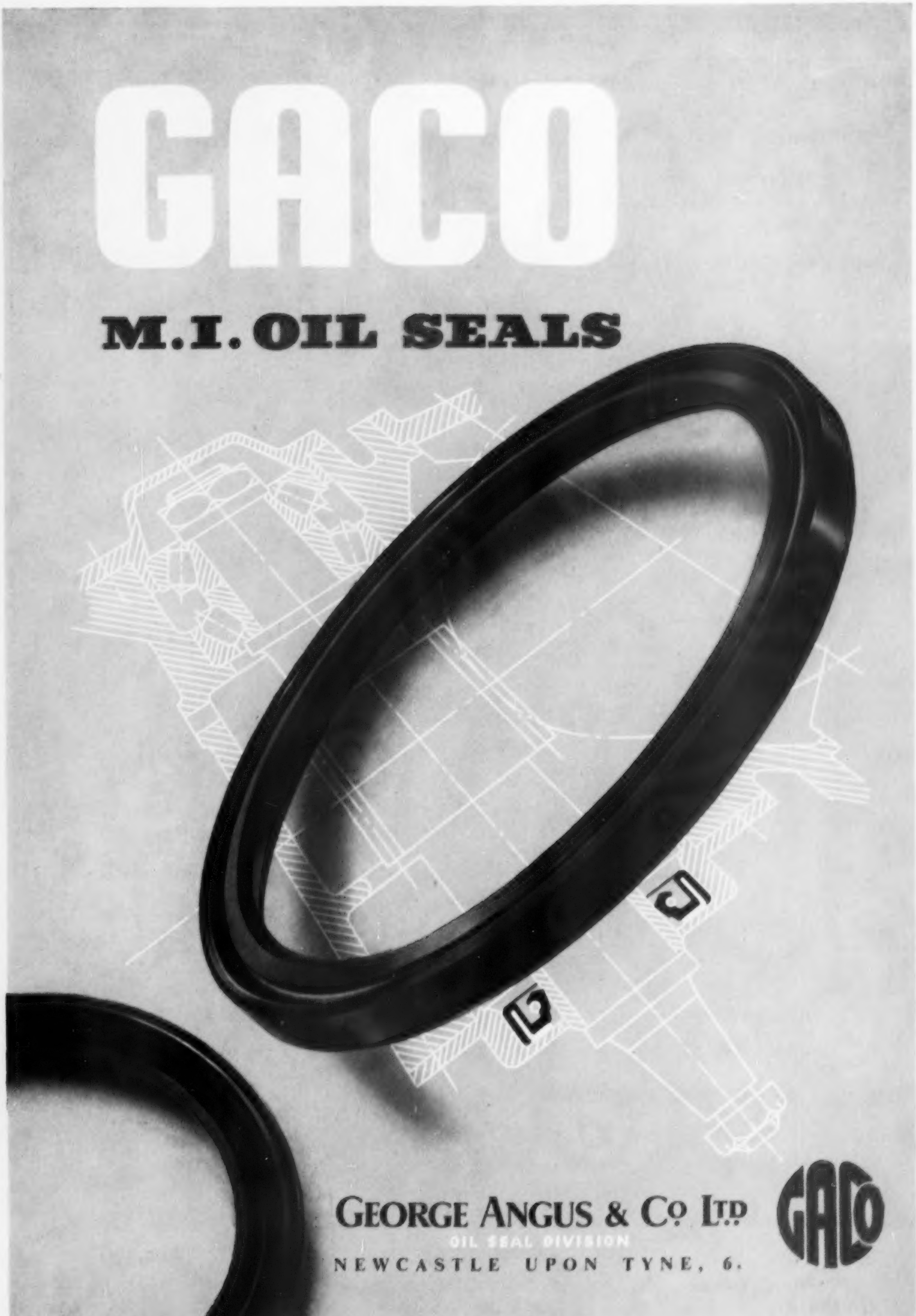
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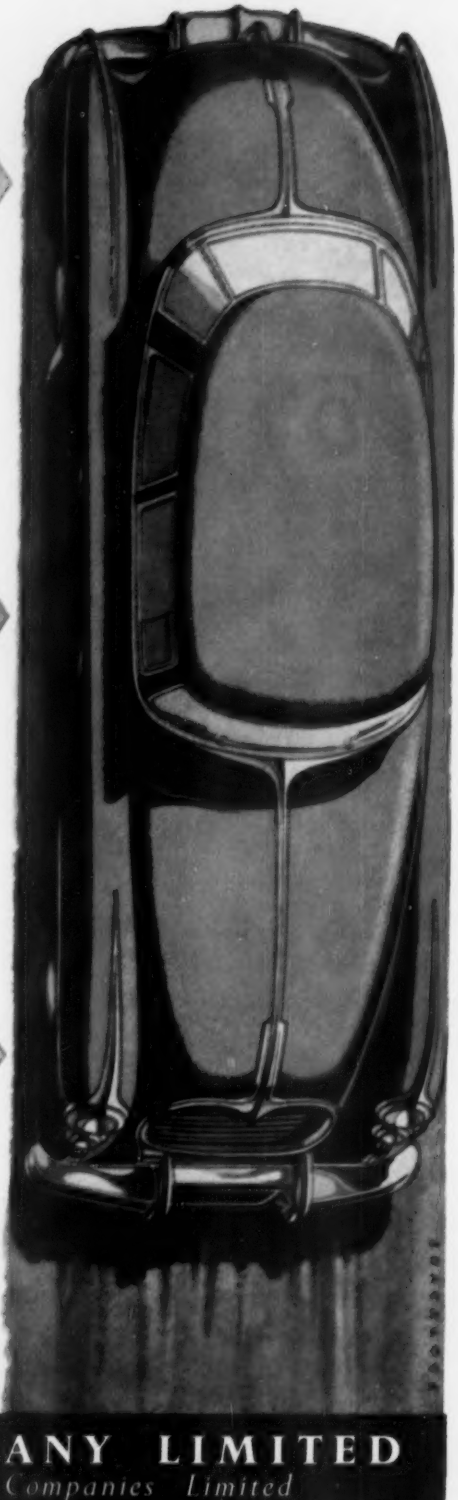

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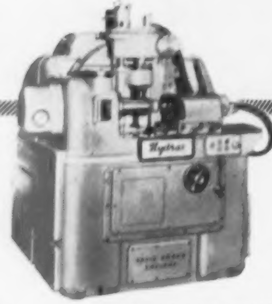
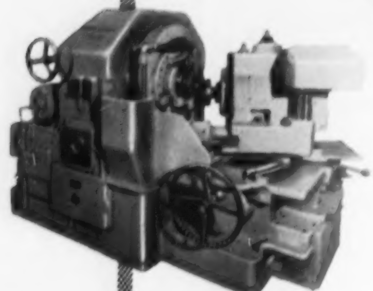
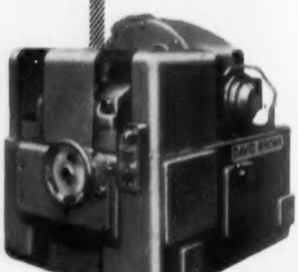


NO. 7 HYDRAX PRODUCTION GEAR HOBBING MACHINE

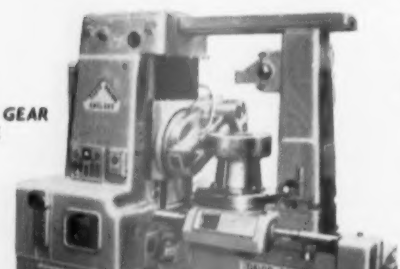
NO. 14 HYDRAX PRODUCTION GEAR HOBBING MACHINE



B16 SPIRAL BEVEL AND HYPOID GENERATOR



S6H PRODUCTION GEAR SHAVING MACHINE



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NEW additions to the David Brown range!

Nos. 7 and 14 Hydrax automatic high speed production hobbing machines for gears up to 7 and 14 inches diameter.

PH30 automatic high speed production hobbing machine for gears up to 30 in. diameter.

S6H and S12H automatic production shaving machines for gears up to 7 and 12 in. diameter.

Spiral bevel and hypoid roughing, finishing, jobbing, testing and lapping machines.

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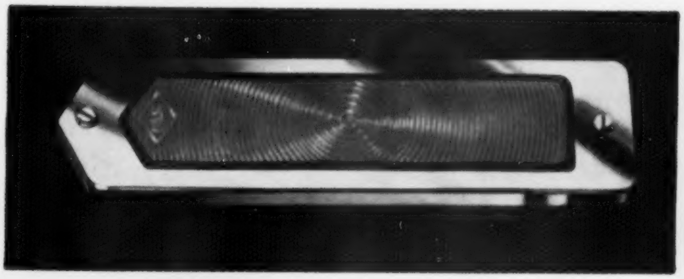

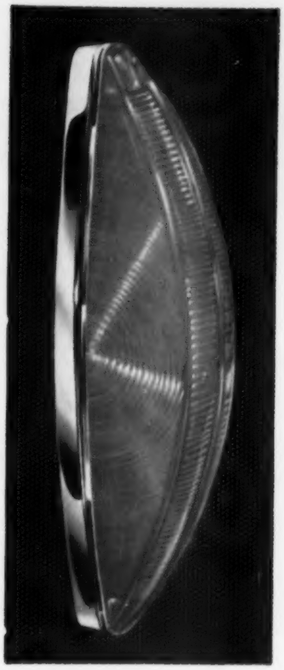

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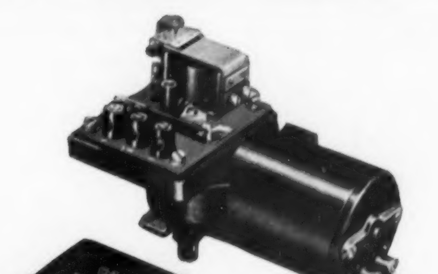
FLASHER INDICATOR EQUIPMENT



Motor driven flasher unit with cover removed.

Self-cancelling switch with warning light.

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Conveniently grouped controls reduce fatigue and speed up handling. Wide vision cab gives full view of work area.

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Now—whether there's drying equipment available or not—you can take on rush spray jobs with Berger Viton half-hour Synthetic Enamels.

Straight from the gun, they give a lasting, high gloss finish—gleaming bright without a 'rub'—and the vehicle can be driven away in half an hour if necessary.

SIMPLIFIED MIXING SCHEME

As well as an extensive range of manufacturers' standard colours, there is the VITON MIXING SCHEME which will enable you to produce an approximate match immediately and economically.

This scheme consists of only 14 basic colours plus black and white; a mixing formulæ book and a simple measuring stick are available FREE. The formulæ cover the standard colours of the leading car manufacturers. The skilled operator can also match colours not covered by the formulæ.

THAT 'SHOWROOM' FINISH

Viton isn't only for rush jobs. You can bring a Viton finish up to a glittering 'showroom' perfection by a quick burnish with Viton Smoothing Compound, and a final polish with "Lifeguard" liquid polish.

For all Refinishers, Viton is the way to new business, to extra profit—at the lowest possible cost.

Why don't *you* start using it right away? It is easily available through your local factor. Phone him about supplies today.

VITON

Half-hour Synthetic Enamels

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FOR BETTER THAN NEW FINISHES!

If a *concours d'elegance* winning standard is required, respray with Proxcelin cellulose enamel. There is a Proxcelin Mixing Scheme, too. Your factor has supplies.

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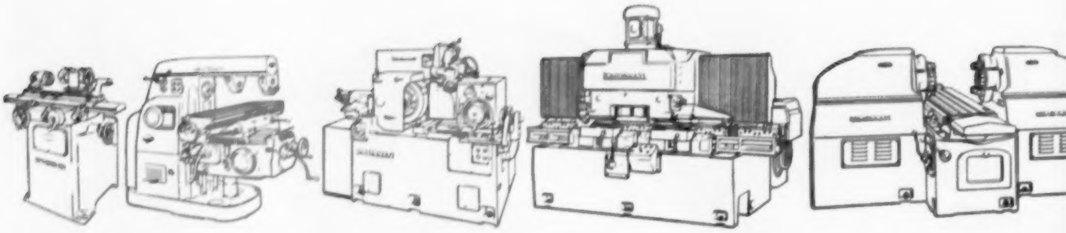

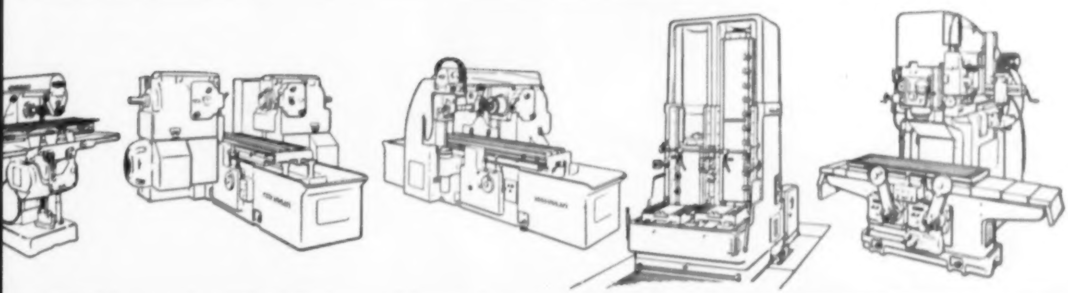

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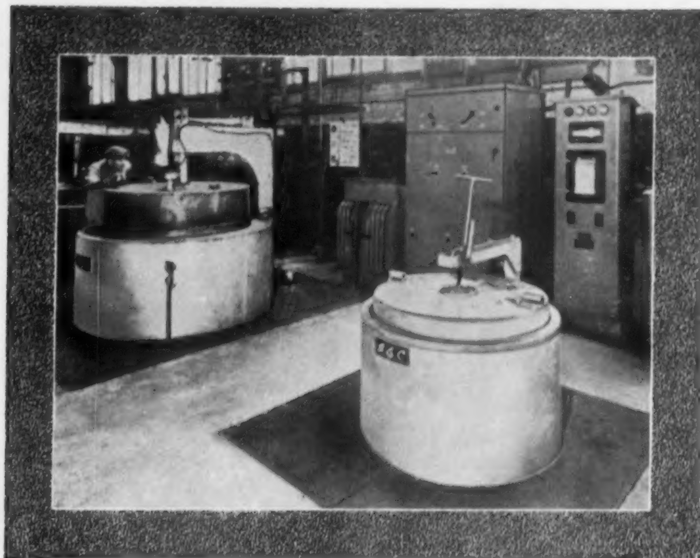
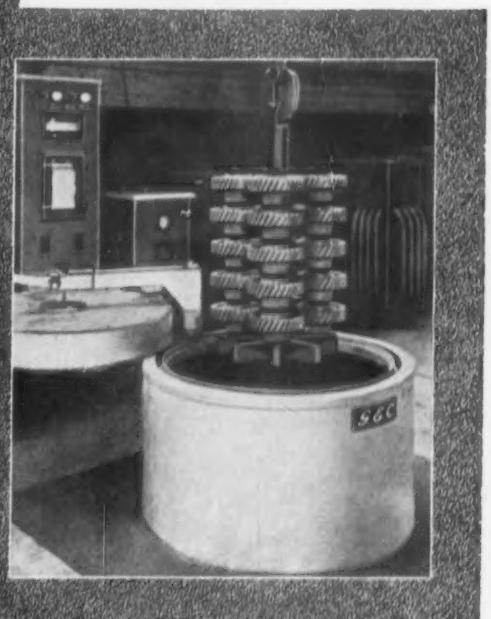


G.E.C. batch type carburising furnace and cooling chamber.

VICKERS-ARMSTRONG USE G.E.C. FURNACES FOR GAS CARBURISING GEAR WHEELS



A charge of gear wheels being removed from the cooling chamber.

At their Elswick and Scotswood Works, Vickers-Armstrong (Engineers) Ltd., have recently installed two batch furnaces with separate cooling chambers—for gas carburising gear wheels—and a continuous hardening furnace with a roller hearth.

The processing atmospheres in the furnaces are generated from a liquid mixture introduced by a drip-feed technique.

The furnaces were designed and supplied by the General Electric Co. Ltd., who also developed the special fluid used for generating the atmospheres.

A gear being removed from the roller hearth furnace for quenching.

For efficient process heating use

G.E.C.

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HIGH FREQUENCY
INFRA-RED

THE GENERAL ELECTRIC COMPANY LIMITED
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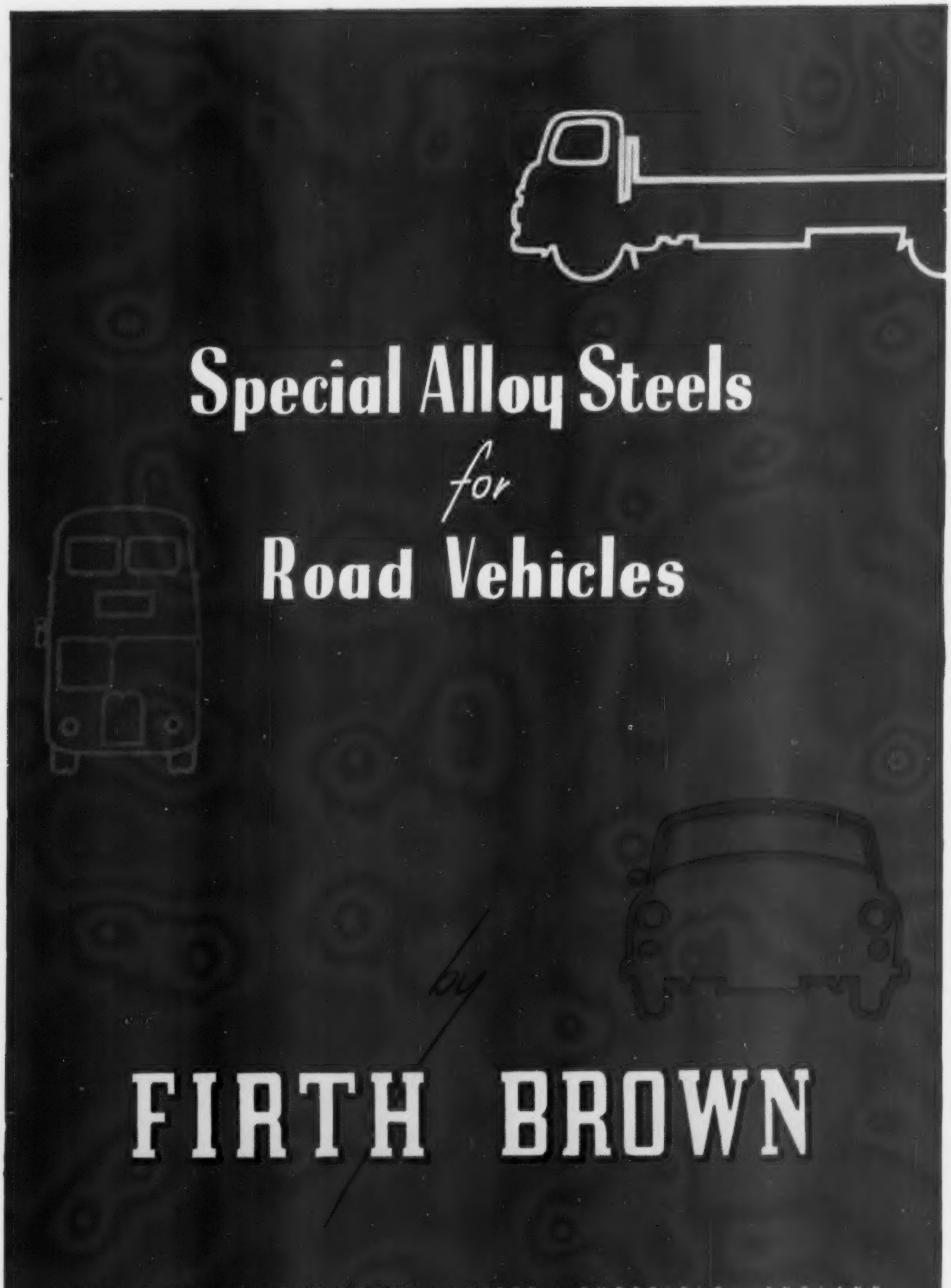
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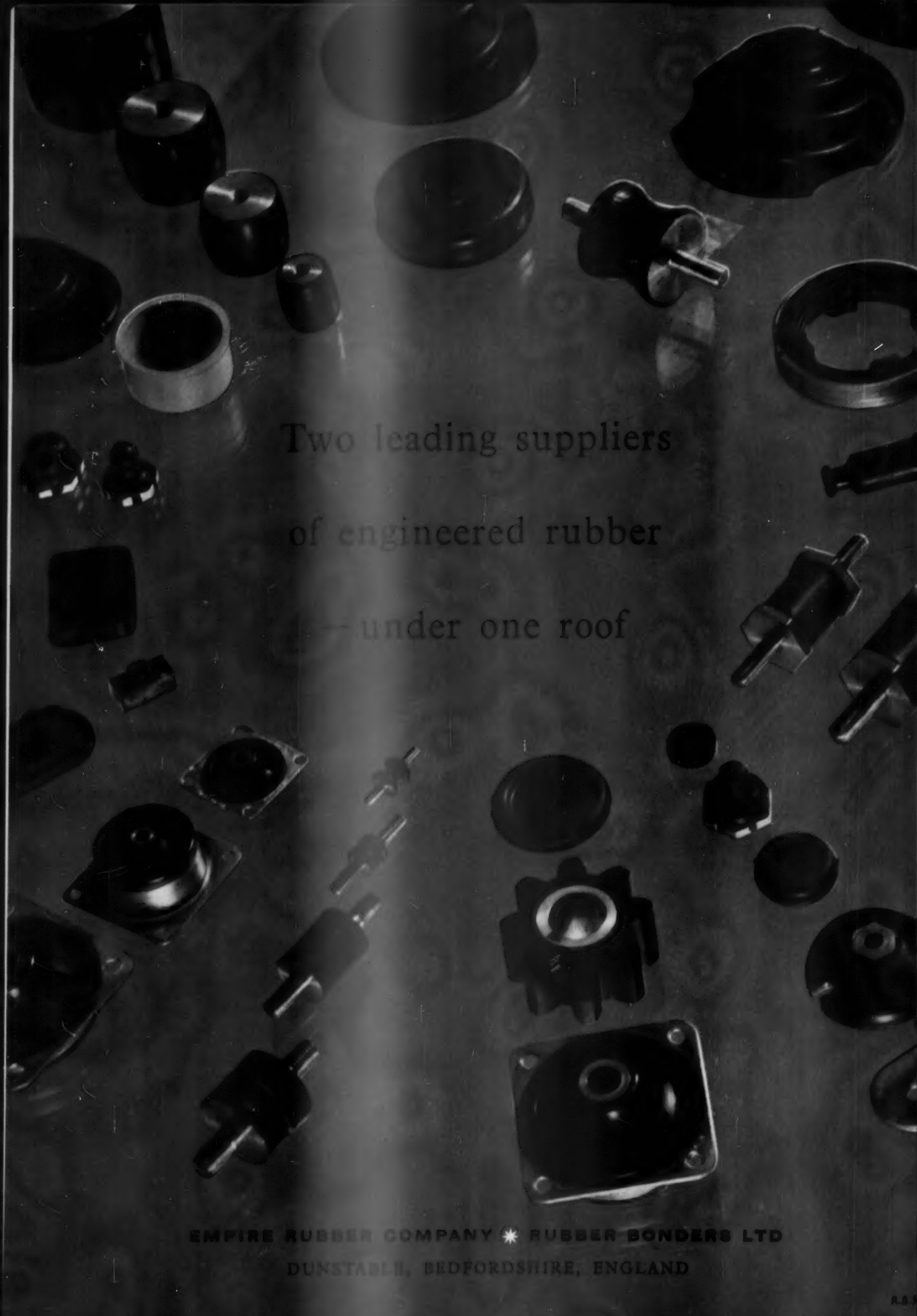
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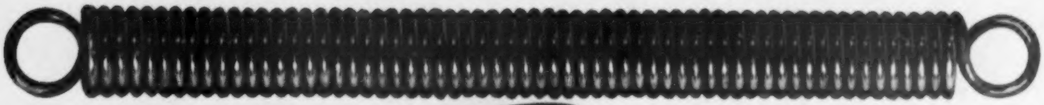
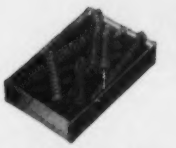
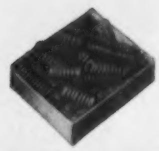
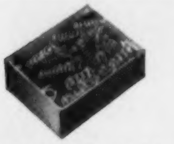




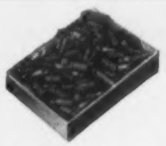
No. 760. 3 doz. Assorted Light Compression Springs 1" to 4" long, 22 to 18 S.W.G., $\frac{1}{4}$" to $\frac{1}{2}$" diam. 6/6 each.



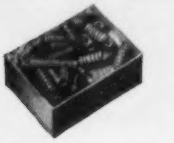
No. 98A. 3 doz. Assorted 1" to 4" long, $\frac{1}{8}$" to $\frac{1}{4}$" diam., 19G to 15G. 5/6 each.



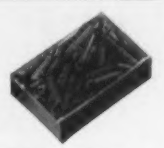
No. 757. Extra Light Compression, 1 gross assorted, $\frac{1}{8}$" to $\frac{3}{8}$", $\frac{1}{4}$" to 2" long, 27 to 20 S.W.G. 15/- each.



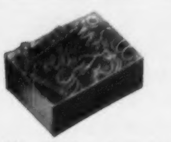
No. 388. $\frac{1}{2}$ gross Assorted Small Expansion Springs. $\frac{3}{4}$" to $1\frac{1}{2}$", 18G to 21G. 9/6 each.



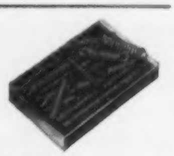
No. 758. Fine Expansion Springs. 1 gross Assorted $\frac{1}{8}$" to $\frac{1}{4}$", $\frac{1}{2}$" to 2" long, 27 to 20 S.W.G. 15/- each.



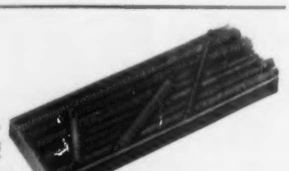
No. 466. $\frac{1}{2}$ gross Assorted Small Expansion Springs $\frac{3}{4}$" to $1\frac{1}{2}$" long, 3/32" to 3/16" diam., 21G to 24G. 6/6 each.



No. 1013. 1 gross Small Coil Compression Springs, $\frac{3}{8}$" to $1\frac{1}{2}$" long, 3/32" to $\frac{7}{16}$" diam., 24G to 19G. 6/- each.



No. 753. 3 doz. Assorted Light Expansion $\frac{1}{4}$" to $\frac{1}{2}$" diam., 2" to 6" long, 22 to 18 S.W.G. 10/6 each.



No. 1024. 20 Compression Springs 12" long. $\frac{1}{8}$" to $\frac{1}{2}$" diam. 24G to 18G, suitable for cutting into shorter lengths; and 30 Expansions $1\frac{1}{2}$" to 12" long, 5/32" to $\frac{3}{8}$" diam., 22G to 16G. 24/- each.

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Heavy-Duty Grinder.

LSR 21
High-Speed Grinder.

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Remember the man that's got to use them when it comes to air grinders. He'd choose this Atlas Copco range. They're streamlined, light, simple to operate and *quiet !* He'd also go for the advanced safety features and the vane-type air motors with their *higher* power output. So next time you're buying air grinders, think of *increased* production, *lower* maintenance and running costs, and the man who'd work better with an **Atlas Copco** machine.

Give that man an Atlas Copco air grinder

Atlas Copco is the world's largest group of companies specialising in the development and manufacture of compressed air equipment. It embraces thirty-one Atlas Copco companies and twenty-four agents, manufacturing or selling and servicing Atlas Copco equipment in more than fifty countries.

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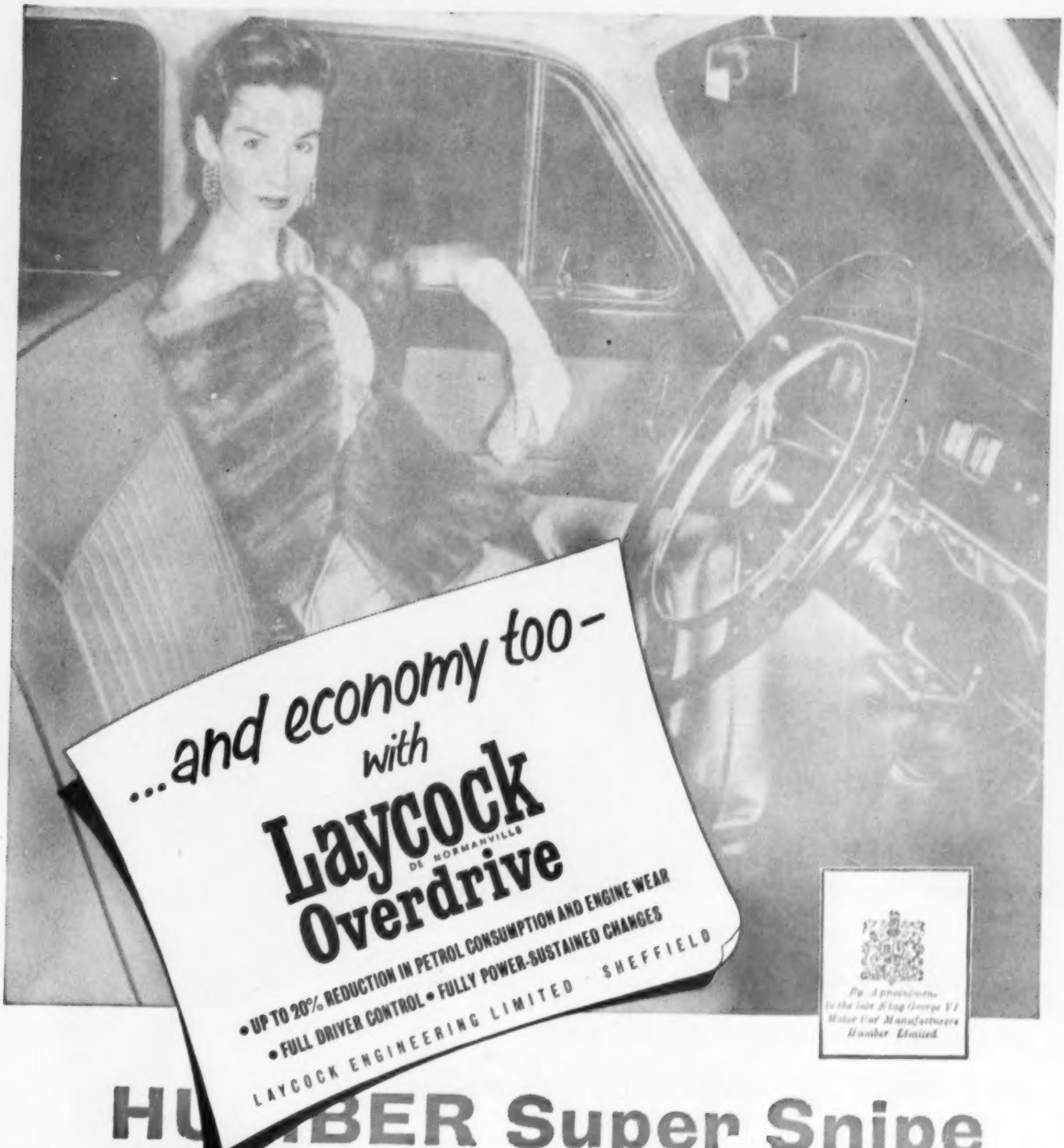

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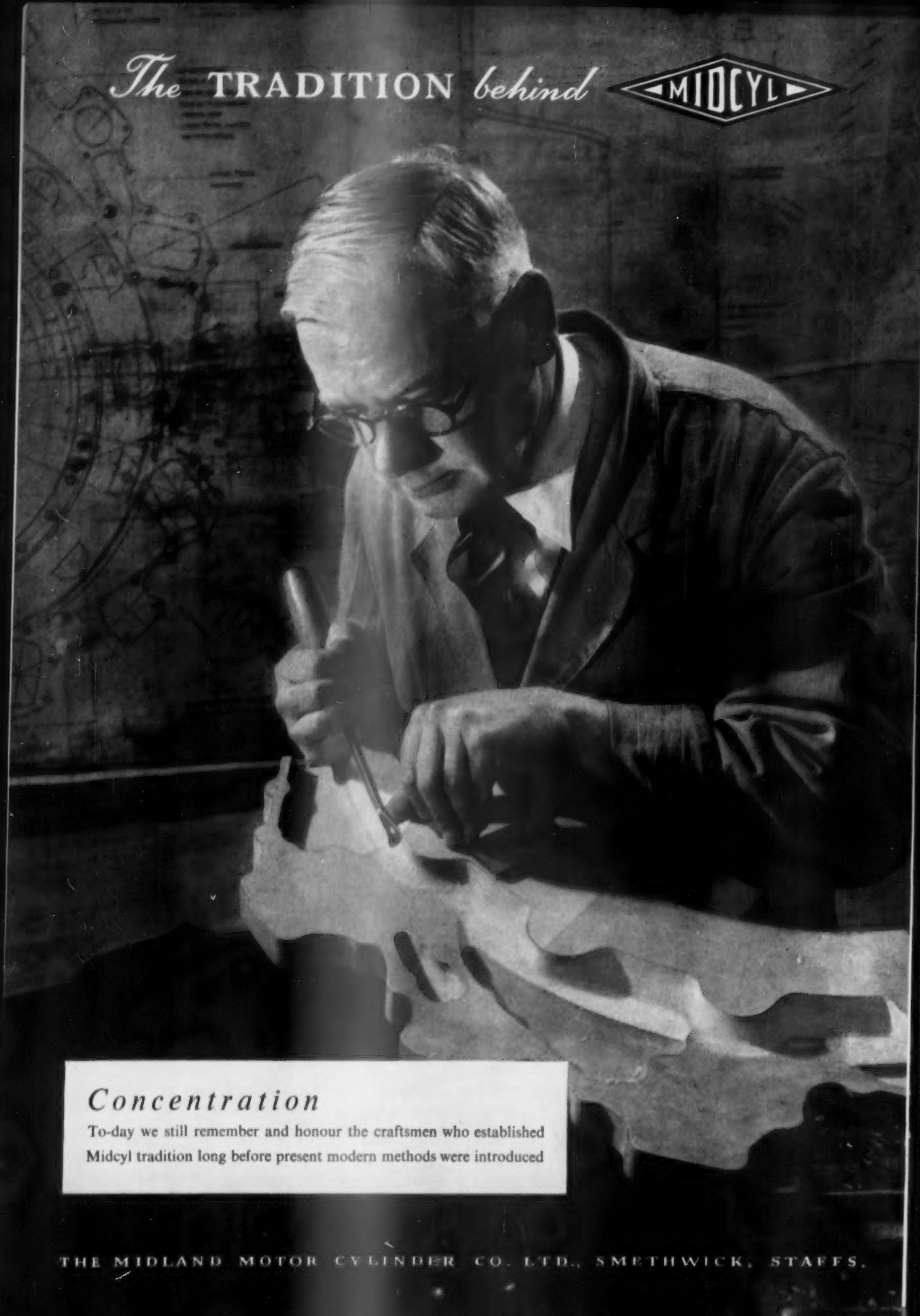
The TRADITION behind MIDCYL
Concentration
To-day we still remember and honour the craftsmen who established Midcyl tradition long before present modern methods were introduced
THE MIDLAND MOTOR CYLINDER CO. LTD., SMETHWICK, STAFFS.

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DESIGN MATERIALS **AUTOMOBILE ENGINEER** PRODUCTION METHODS WORKS EQUIPMENT

Mechanization or . . . . ?

THERE has been, and still is, so much loose thinking about "automation" that it is desirable to return to a subject that has already been discussed in these columns on several occasions. It is unfortunate that the philologically monstrous term "automation" is now generally applied to developments in the mechanization of productive processes in the automobile industry. Words do not exist *in vacue* but depend for their currency upon the ideas that they evoke, and unhappily automation has already become associated with ideas which, although mistaken, can lead to serious trouble in an industry that is striving for greater efficiency. To many people, automation is now a bogey word, whereas, in fact, it is merely an unpleasant and unnecessary neologism for two more precise terms, mechanization and instrumentation.

A steady increase in the mechanization of production processes has, of course, been a feature of the engineering industries since the first industrial revolution. The rate of change has varied from industry to industry, and so far as mechanical engineering is concerned, the automobile industry, a comparatively latecomer in the field, has shown the greatest readiness to adopt new techniques. And with what remarkable results! For instance, in a typical factory of 1906 the production of a motor car took 7,000 man-hours, whereas in the same organisation the figure to-day is 175 man-hours. The difference is certainly mainly, in fact almost wholly, due to increased and improved mechanization of processes. Nor has the speeding up of production led to unemployment. On the contrary, the labour force in the organisation in question is now more than 800 times greater than it was 50 years ago. These figures may be regarded as fairly typical of the entire industry.

Not only has the industry become one of the largest employers in the country; it has also been one of the best. The earnings of the workers have always been above the average, and since the war have been the highest in the country, for engineering generally. There can only be one answer to the question: How has the automobile industry so greatly expanded its markets, and hence its labour force, while maintaining high rates of earnings for the workpeople? It is—improved production methods. That is, through increased mechanization, leading to reduced costs and lower prices to make a motor car a practical proposition for a greater number of people.

If the British industry is to maintain its position in world markets, there is now pressing need to keep prices stable, or better still to bring them down. Continental competition is keener than ever, and it is not beyond the bounds of possibility that if the present recession in the American automobile industry continues, efforts will be made to find more export outlets for American cars. It may be objected that the almost world-wide dollar shortage makes this unlikely. However, the prosperity of the automobile industry is now virtually regarded as the prosperity index for the whole of the U.S.A. and it would not be surprising if strong efforts are made to find overseas markets for production in excess of home demand.

Without in any way decrying the importance of design development, we must say with the strongest emphasis that the all important matter for the British industry to-day is a reduction in costs with a consequent reduction in prices. Unfortunately, the vehicle manufacturer has no control over at least 70 per cent of his costs; therefore it is essential to exercise the most stringent economies with regard to his own production. The adoption of advanced production techniques is one of the most important factors for effecting this result.

In great measure, it is the very prosperity of the workers in the industry that lies at the root of their opposition to further mechanization. Workers are understandably loth to leave an industry in which high earnings can be obtained without laborious effort and where, in many cases, only a modicum of skill is needed—because the existing standard of mechanization has eliminated most of the toil and most of the need for any great degree of skill.

For both short and long term policies it is an inescapable fact that the industry can remain prosperous only if the maximum possible use is made of technological advances. As a short term policy this is necessary for maintaining prices at a competitive level. If this is not done, we shall have a reduced labour force on lower individual earnings.

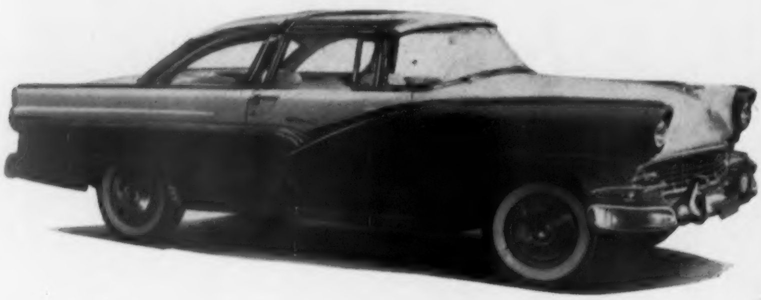
As a long term policy for the automobile industry, and indeed for all industries, increased mechanization is a necessity if the present standard of living is to be maintained or improved. We in this country are faced with a population problem in which those of working age will progressively represent a smaller percentage of the total. Therefore, every worker must produce more, and the easiest and most logical way to effect this is by making the machines do the maximum work.

The Ford Fairlane Victoria Fordor model is an example of the four-door pillarless hard top design that is becoming very popular in the United States of America

American Bodywork

A Review of the Latest Trends and Details of Outstanding Interest

Another model of the Ford range is the Crown Victoria Skyliner. This vehicle can be supplied either with a conventional steel roof or with a tinted transparent portion, fitted with a blind, in front of the hoop extension of the two centre pillars



WHEREAS in Europe, ownership of a car is considered to be something out of the ordinary, the American owner regards his vehicle as almost as much of a necessity as, for example, a house. Therefore, the American market differs from the European one in that customers tend to look with favour on cars that incorporate novelties that make them different from the cars that their neighbours own. For example, one model is offered with seat and squab cushions which are trimmed with different materials on each side and are reversible so that the appearance of the interior of the car can be radically changed in a matter of seconds. It is difficult to see that features of this type serve any really useful purpose but apparently they have sales appeal.

The four-door hard-top type of design is gaining in popularity. In the medium price field, 30–40 per cent of General Motors' car output is of this type of vehicle, and in the low price field, the figure is about 20 per cent. There is also a trend towards the introduction of less gaudy colours than hitherto. More metallic tones, in addition to grey, green and blue, are being introduced. Where two or more colours are employed in the interior, most manufacturers are now offering harmonizing colours rather than two different shades of the same colour.

Dodge

Among the four-door hard-top vehicles is the Dodge Custom Royal Lancer. The essential feauture of this type of design is that the centre pillar, on which the rear door is hinged, does not extend above the waist level. With this semi-pillarless construction and wrap round front and rear windows, the all-round visibility is exceptionally good. This layout also has advantages so far as styling is concerned, in that the vertical line of the centre pillar is eliminated. Thus, the horizontal lines of the waist, cant rail and roof accentuate the length of the vehicle and the top-heavy appearance that is characteristic of a number of American cars is avoided. This type of design obviously is easiest to apply to a car with a separate chassis frame; however, pillarless designs have been successfully adopted in Europe for smaller chassisless vehicles, for example, the Lancia Appia.

In the Custom Royal Lancer, as viewed in side elevation, the centre pillar tapers to a point at the top. At the base, it is reinforced by generous fillets. A thin triangular gusset plate, covered with leather cloth, is fitted between the top of the pillar and a point a few inches forward of its base. This plate is in line with the front seat squab so it in no way obstructs the entrance to the vehicle. Presumably, the function of this gusset is to support the weight of the rear door when it is in the almost closed position. There is no problem so far as support for the door in the open position is concerned, because the thickness of the pillar, as measured in the transverse plane, is more than adequate to give it the necessary stiffness in that direction. Similarly, the pillar is more than adequate to take the loads due to the slamming of the front door. When both doors are shut, the pillar cannot be seen from the outside, becuse it is overlapped by the edges of the door panels.

Ford, Lincoln and Mercury

The Lincoln Première range of vehicles incorporates a number of novel features. At the front end, the headlamps are hooded, as in most American designs, but the background under the hood is a dummy grille. The radiator grille comprises an exceptionally heavy central horizontal bar with three chromium plated strips above and three more below it to protect the grill opening. The upper edge of the opening is formed by a light chromium plated section. At the lower edge there is a heavy chromium plated section which, together with the central bar, forms the bumper. Lamps are mounted in both the central and the lower bars. This arrangement does not lend support to the suggestion that heavy bumpers are essential in America as a first line of defence against damage to body panels.

An unusual feature of this design is that the lower edge of the wing panel on each side is horizontal from the extreme front end to the point where it is swept down behind the wheel. The ends of the centre and lower bars of the grille join and are turned sharply round the sides of the vehicle, and the upper edge of this assembly fits under the front end of the horizontal lower edge of the wing panel on each side. A good feature of the arrangement is that the ends of the two bars that form the bumper are wider than any of the body panelling on the vehicle. They are also turned inwards so that they do not tend to catch obstructions when the car is being reversed.

On the sides, a horizontal line extends from the base of the headlamp hood at the front to the corresponding point on a similar hood over the rear lamps. As viewed from the side, the profile of the front lamps is raked forwards while that of the rear lamps is raked back. The coloured glass of the rear lamp on each side is bowed and projects beyond the hood so that the light is visible from the side as well as directly from the rear. Another feature that is used to accentuate the horizontal lines of the vehicle is a chromium plated strip extending from a point immediately behind the front wheel to the rear bumper. The upper edge of this strip is horizontal, but its lower edge falls as it sweeps to the rear. At the back of the vehicle, the exhaust pipes discharge through apertures in the bumper. This gives a clean line below the bumper and also tends to prevent the possibility of reverse flow of exhaust under the body floor.

On the dash facia, also, horizontal features are accentuated. All the instruments are housed under a rectangular cowl on top of the facia. From left to right, they are: a hand brake warning lamp, coolant temperature gauge, trip speedo and fuel gauge, oil and dynamo charge warning lamps and a clock. There is an inverted cowl of similar form immediately below the facia. This balances the upper one so far as appearance is concerned and carries most of the

Lamps are incorporated in the bumper of the Lincoln Première

Interior arrangement of the Ford Fairlane Sunliner. An unusual feature is the chromium plated pressing above the rear seat squab

switches, in line on a chromium plated face plate. The heater control levers are to the left of the steering column and they operate in quadrants formed by vertical slots in the facia. There are four levers, and behind each pair is a small rectangular cowl under which is a rotating indicator to show whether the heaters are on or off. This feature appears to be an unnecessary complication in view of the fact that indication could be effected equally satisfactorily and more simply by markings on the quadrant. However, it is neat in appearance. As in most American cars, a cigar lighter is provided for the driver. It is mounted on the switch panel beneath the facia. Another electric lighter is provided, together with an ashtray, in each of the two armrests for the rear seat. When not in use, they are concealed by a horizontally sliding, chromium plated lid.

The steering wheel is unconventional in that the two spokes are inclined so as to give the hub, spoke and wheel assembly a cupped appearance. Not only does this protect the horn ring against being accidentally knocked by the driver when he is entering or leaving the car, but also a thumb can be used to operate the horn without taking the hand off the steering wheel and, most important of all, in the event of a head-on collision, there is less risk of injury to the driver owing to his coming violently into contact with the unyielding hub of the wheel. Round the hub there is a small glass-faced annulus, which is the indicator for the automatic transmission. The letters P R N Dr Lo are painted on the glass and the position selected when the lever is actuated is indicated by a white circle on a black background plate beneath the glass. This circle surrounds the letter that indicates the position selected.

An unconventional feature of the interior handles of the door locks is that they are surrounded by a 5in diameter

dished chromium plated escutcheon. Presumably the reason for the employment of such a large diameter escutcheon is that it prevents the white trim from being soiled if dirty hands operate the release lever. All the windows are electrically operated, as also is the seat adjustment. The handle that locks the rectangular glass ventilating panel between the sliding glass and the pillar of the wrap-round windscreen is large and has a spring-loaded button at the centre, which has to be depressed to unlock it. The current trend in America towards the use of larger handles for these ventilating panels is a good feature because the small ones hitherto employed were difficult to operate and tended to be fragile.

Another unusual feature of the vehicle is that the free ends of the rails that carry the sun visors are supported in U-shaped clips on the screen head rail. They can be lifted out of the clips, so that the rails can be pivoted round for the visor to screen the side windows. The reason why these clips are fitted is that if the ends of the long rails are unsupported, vibration tends to cause the visors to fall down slowly.

The Mercury Montclair incorporates many of the features of the Première, but the dash arrangement is entirely different. Above steering column, the instruments are housed behind a glass which is in the shape of a segment of a circle between the arms of an obtuse angled V-frame. The glass is divided into three by chromium plated rails parallel to the periphery of the segment. The lower portion of the glass covers the mileage indicator, the central portion is over the speedometer and the upper portion covers the remainder of the instruments which are, from left to right, the ammeter, fuel contents, oil pressure and water temperature gauges. On each side of the V there are two quadrants for the heater controls. The radio is in the centre of the facia and the clock is to the right of it.

Ford also make a four-door hard top vehicle as one of the models of the Fairlane Victoria range. This differs from the Dodge in that the centre pillar below the waist is appreciably wider, as viewed in side elevation. The Fairlane Sunliner, which is a two-door drop head version of this vehicle, incorporates a number of unusual features in the interior arrangement. A large chromium plated garnish-plate is fitted along the top of the forward edge of the tonneau cover. The centre of this plate is V-shaped and extends down into a U-shaped cut-out that divides the upper edge of the rear seat squab. Some of the seat and side trim panels are covered with a quilted material.

Again, this car incorporates many of the features that are common to the Mercury Montclair and Lincoln Première models. One of these is the dished form of steering wheel. However, whereas in the Première a two-spoke wheel is employed, those on the Montclair and Fairlane models have three spokes. The dash of the Fairlane range of vehicles is entirely different from that on others. The instruments are under an exceptionally large hood, which prevents reflections at night. All the instruments have conventional circular faces. The central one is the speedometer, and the fuel contents and water temperature gauges are on each side of it. Below these three, which are immediately above the steering column, are the clock and warning lamps. The clock is to the right of the column and the oil pressure and generator charge warning lamps are behind a single circular glass to the left of the column, but are separated by a horizontal bar across the centre of the glass. The heater control levers move horizontally in their quadrant to the right of the steering column and the radio, which is midway between the ends of the facia, is to the right of this quadrant.

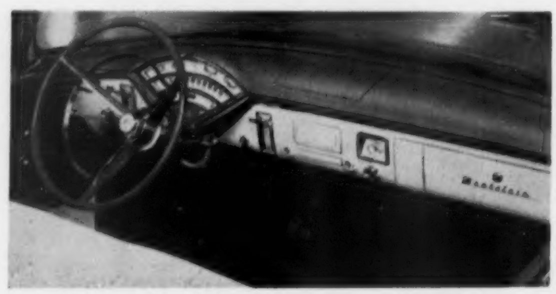
Nash

The Nash Rambler range includes a number of models such as the four- and two-door saloons and pillarless hard tops and an estate car. A glance at the illustrations of the four-door pillarless hard top and estate car versions shows how the design has been developed with a view to making as many of the body panels as possible common to the whole range. All these models are built on a common basic structure. At the front end, a double transverse wishbone link type of suspension, with the coil springs on pedestals on top of the swivel pins, is employed. The upper end of each spring abuts against a plate under the horizontal portion of the valance panel above the wheel. Thus, the major part of the vertical loading is taken directly from the top of the swivel pins to the wheel valance panels. There are two rods, one in front and the other behind each spring to tie the plate against which the upper end of the spring abuts to the box section longitudinal member at the base of the valance panel.

The bottom ends of the telescopic shock absorbers are connected to the lower wishbone arms. Their upper ends are attached to brackets on the valance panels. The pivot pins for the upper wishbone links are carried in channel section pressings welded vertically to the valance panels. On the other hand, the lower wishbone arms are pivoted on the ends of a cross member bolted under the two longitudinal members. The engine is mounted on two top hat section cross bearers, one in front and the other behind the suspension cross member. An interesting feature of the insulation of the body panels is that a $2\frac{1}{4}$in thick pad of resin-bonded glass fibre is struck to the undersurface of the bonnet lid, on each side, above the suspension spring platforms. Between these pads, which are large and rectangular in shape, a sheet of bituminized felt is stuck to the undersurface of the lid.

With the wrap-round type of windscreen, front end rigidity is most important, otherwise there is a danger of

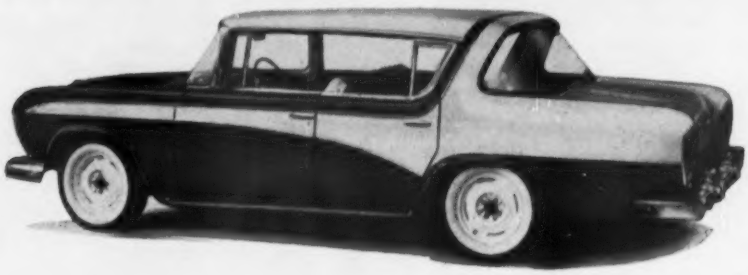
Horizontal features are accentuated on the Lincoln Première facia



As in most of the Ford, Mercury and Lincoln models, the steering wheel and horn ring assembly of the Montclair is of cupped form

The estate car version of the Nash Rambler has a large winder type handle on the exterior panel of its rear door. This handle, which can be locked, is used to lower the glass to give access to the hook and eye type door catches on the interior waist rail

Most of the body panels of the Nash Rambler four-door pillarless hard top saloon are common with those of the estate car. The large section hoop extension of the rear pillars is said to protect passengers if the car rolls over after a crash



breakage of the screen due to flexure of the body. The weakest point is inevitably where the screen overhangs the front door pillar on each side. In the Nash Rambler, the necessary strength and stiffness have been provided by forming a triangular brace on each dash side panel. The base of the triangle is the door pillar, one side is stiffened by the junction of the rear portion of the wheel arch with the dash side panel and the third side is a pressing that forms a continuation of the overhung portion of the lower rail of the screen frame. The drip channel, to carry away the water that runs over this overhung portion and into the door opening, is a soft rubber section that also forms the dust seal. Thus, an economy has been effected by making the one component perform two functions.

The door pillars, cant rail and sill on each side form the main longitudinal members of the frame of the vehicle. Additional strength is furnished at the rear by extending the door shut-pillar upwards to form an arch, following the contours of the roof. This is to protect the passengers should the car roll over. Nash make a special feature of safety in their sales literature. The lamp glasses at both the front and the rear are bowed in plan, and they can be seen from the side as well as from the front and rear. Another safety feature quoted is the strength afforded by the combined engine bearer and wheel valance panel assembly at the front end.

At the rear, the body sills are swept up over the wheels and then down again to support the boot floor. An unusual feature of this arrangement is that the sills remain out at the full width of the body instead of being swept inwards. The rear suspension is of the through-axle type with coil springs. It is located by a Panhard rod and the torque tube type propellor-shaft drive. The ends of the axle are tied by means of rods to the torque tube in the usual manner. Between the wheel arches is a deep section cross member formed by pressing the seat pan and boot floor into a top hat section shape. This cross member takes the suspension loads.

Inside the vehicle, the front seats are of the reclining type and their squabs can be laid down horizontally to form beds. Either a Weather Eye heating and ventilating system or an All Season air conditioning unit can be fitted. The All Season system includes a refrigerator, with its heat exchanger interposed between the grille and the radiator. An unusual feature of the layout is that it is all housed under the bonnet, so that the boot is left entirely free for luggage.

In the estate car version, a door is fitted at the rear. It is hinged at its lower edge and carries a drop glass, which is raised or lowered by an unusually large handle on the outer panel. This handle can be locked. The door release catches, which are of simple hook and eye form, are on the inside, so the window has to be opened before they can be released. This arrangement undoubtedly has been adopted to ensure that the window is lowered before the door is opened and therefore is not likely to be damaged.

The rear seat squab and cushion fold forwards to form a flat floor for luggage. All of the floor and the back of the seat squab is covered with rubber. Square pieces of carpet are stuck in wells in the floor for the rear passengers' feet. As in the other models, the front seat squabs can be laid back against the cushion of the rear seat to form beds.

Oldsmobile

The Oldsmobile Super 88 is another of the American vehicles in which the grille and bumper are combined and lamps are fitted in the lower bar. The headlamps are in hooded forward extensions of the wings. In this vehicle these hoods are formed by the large chromium plated lamp bezels, whereas in most of the other recently introduced American cars, they are part of the wing panels and pastics bezels act as fillets between the hood and the lamp. The plastics finishers are in most instances secured by counter-

The Oldsmobile facia is readily adaptable to left- or right-hand drive

sunk drive screws sometimes concealed by a chromium plated finisher strip. At the rear end of the vehicle, the profile as viewed from the side, has a forward rake; it is now more usual for American cars to have a backward rake to balance the forward rake of the front end. The rear lamps of the Oldsmobile Super 88 are high up on the trailing edges of the wings. Their glass and bezel assemblies are shaped like the nose of a torpedo and project to the rear.

The dash facia arrangement is particularly good. In general appearance, the layout resembles a pair of spectacles, with a straight elongated central bridge-piece. The clock is in the eye-piece on the right-hand side and the instruments are in that on the left. Between the two, the radio is mounted in the centre of the horizontal chromium plated bridgepiece. The horizontal lines are accentuated by bars extending outboard each side of the eye-pieces, and also by the fact that the glasses and their chromium plated bezels are oval instead of round, with their major axes horizontal. This layout would be well suited to a vehicle designed for alternative left- and right-hand drive arrangements.

Packard and Studebaker

The front end of the Packard Caribbean still has a forward rake, as illustrated in the April 1955 issue of *Automobile Engineer*, but in this year's model the grille is swept, as viewed in plan, instead of straight. Although the sweep is only slight, it is a marked improvement, since it obviates the tendency for the flatness of the grille, characteristic of last year's model, to clash with the curved lines of the surrounding body panels. The profiles of the front edges of the hoods over the headlamps, as viewed from the side, also are curved instead of straight. On the bonnet lid there are two dummy air intakes, one on each side, apparently to break up the plain appearance of the bonnet panel. The rear end styling has been modified to incorporate a backward rake to balance the forward rake at the front. As is usual with this arrangement, the rake is formed by the trailing edge of the rear quarter panel, and the bowed glass over the lamps does not follow it but is arranged vertically so that it is visible from the sides.

On each side of the vehicle, there is a horizontal chromium plated strip extending from the top rail of the grille at the front to a point about 7in from the rear end where it turns sharply up, parallel to the rake of the rear edge of the panelling. The line of this upturned portion is continued by a radio aerial which projects at the same angle from the top of each rear wing. The practice of fitting the aerial at the rear is becoming widespread, despite the fact that the wiring arrangements inevitably are more complicated than when it is fitted on the scuttle. Beneath the horizontal strip, there is a broad band painted a different colour from the rest of the body, and the line of its lower edge is accentuated with a second chromium plated strip.

In the Patrician model, the styling is similar, but the broad band is a grooved chromium plated panel, with the bases of the grooves painted black. Among American cars generally, there is a noticeable trend towards the adoption of broad horizontal bands either painted or formed by wide chromium plated strips. This type of device is effective in breaking up the plain appearance of the side panelling.

There are a number of interesting features in the interior of this vehicle. The head lining is of a material that is either hide or a very good imitation in plastics. It is made from about nine strips, arranged transversely and sewn together to give the required shape. The whole of the area is perforated with $\frac{1}{32}$in diameter holes at about $\frac{1}{4}$in pitch and there is a sound-absorbent material between the lining and the roof panel. Three chromium plated strips are mounted transversely under the lining to hold it up. Chromium plated capping strips conceal the joints at the cant rail. The employment of a perforated covering for a noise-absorbent material is common practice in the design of special buildings and other applications in which accoustics problems arise, but it has rarely, if ever, been used before for the head linings of motor cars. Another unconventional feature of the trim is that the seat and squab cushions are reversible. They are trimmed with hide on one side and a cloth material on the other.

Push button controls for automatic transmissions are gaining in popularity. The Packard models have an electric, push button type control. It is mounted on a pedestal extending from the right of the steering column. A safety device is incorporated to prevent the selection of 'park' or 'reverse' while the vehicle is in motion. The 'park' position is selected automatically when the ignition is off.

To European eyes, the incorporation of a conventional radiator grille on the front of the bonnet lid of the latest Studebaker models is undoubtedly an improvement. The design as a whole clearly demonstrates that clean aerodynamic lines can be obtained without sacrifice so far as styling is concerned

AUTOMOBILE IMPACT STUDIES

Some Aspects of the Engineering Problems Involved in Designing for Safety

J. Anthony Edwards

RECENTLY, a great deal of research work has been conducted in the United States of America on the complex problems of automobile accidents, the aim being at providing maximum protection for the driver and passengers. A few months ago, some of these investigations were described to the Society of Automotive Engineers by D. M. Severy and John H. Mathewson of the Institute of Transportation and Traffic Engineering, University of California. The work was carried out with the co-operation of the Los Angeles police department, since it was decided that field investigations of automobile accidents should be conducted at the scene of the accident. A car equipped for receiving police radio broadcasts was used to visit many accident scenes. An accident investigation form was devised to obtain as much technical information as possible, and case files were developed of typical collisions.

Perhaps the greatest difficulty, even when tests are conducted by engineers, is the lack of means for determining reasonably accurately the car velocity immediately before impact. Motorists' statements following a collision are frequently designed to protect themselves; these motorists are also often in a partial state of shock so that their responses are not entirely reliable. Statements by witnesses are frequently conflicting: it appears that in many instances the witnesses are confused even though they were not involved in the accident. Many collisions occur too quickly for even a group of trained observers to analyse them visually: in these circumstances, only high-speed cameras can provide some of the information.

The problem of devising a controlled but realistic experimental automobile crash was considered. Many variables had to be assessed. They include: the percentage lateral offset of impact, angle of impact, velocities of impact, the masses of the colliding vehicles, ensuring that the vehicles would collide in view of the high-speed cameras, and the problem associated with instrumentation and data recording for two moving vehicles. Also, it was necessary to solve the problem of finding suitable test vehicles, identical with those used in other tests at different impact velocities, so that their structural properties corresponded. After considering these problems, it was decided that for the initial tests, a single automobile would be crashed into a fixed barrier. This eliminated the variables of the opposing vehicle and the problem of knowing where these vehicles would crash. In addition to the barrier collisions, a series of rear-end collisions were conducted for the purpose of determining the cause of serious injuries said to result from relatively light rear-end impacts.

Automobile collision instrumentation

The first attempt to fit a car with instruments for collision measurements appears to have been made by the University of California. Instrumentation for these early tests consisted only of equipment essential for micromotion analyses of high-speed motion picture films of the collision. The apparatus, listed in Table I, has been successfully applied for the collection of data in automobile collision research.

Only specially designed equipment is suitable for collecting data on a collision lasting less than a quarter of a second. A knowledge of the force-time relationships for the various components of the colliding vehicle and its occupants is essential, and it is also valuable to know the time relationship they bear to one another. For this reason, all the electrical signals detected during a collision are recorded on a single multi-channel oscillograph equipped with a crystal-controlled common time reference.

In order to relate the physical observations recorded by

TABLE I. AUTOMOBILE COLLISION INSTRUMENTATION

Mechanical	Electrical	Photographic	Physiological
Car frame and body position indices, to provide permanent deformation data	Strain gauges, for measuring safety belt loading, etc.	High-speed motion picture cameras, for micromotion analysis	Dummy subjects, to provide data on the kinematic behaviour of the human form during collision, and thus to provide an approximate indication of the trauma associated with a particular type of collision
Mechanical accelerometers, to provide acceleration data independent of electrical devices	Electric accelerometers, for providing basic acceleration data	Speed-graphic (still) camera, for blow-up shots at instant of maximum body collapse	Human subjects, for evaluating human tolerance limits to collision for specific restraining devices and for observing kinematic behaviour of the human body during collision
Human subject grease-paint, for providing torso flexure references for kinematic behaviour study	Recording oscillographs, for recording loadings, accelerations and similar information	Moderately high-speed g-resisting camera, for recording subject responses to collision from within car	
	Delay timing circuit, for actuating speed-graphic camera	Standard-speed movie cameras to provide documentary film material	
	Frequency standard, to provide accurate millisecond timing in the field for micromotion analysis	Calibrated marker boards, for micromotion analysis	
	Probe circuit, to give oscillograph record of instant of contact for collision	Reference targets, for micromotion analysis	
		Camera-oscillograph synchronization device, to provide a common time reference	

the camera to the physical factors recorded by the oscillograph, a means of synchronizing these two functions was required. The signal was therefore fed from a magnetic pickup on the drive wheel of the camera to one channel of the oscillograph through a line between the camera and the mobile instrument truck. The camera film speed is identified by a 60 c/s timing-light marking on the edge of the film. The photographic paper speed of the Hathaway recording oscillograph is identified by the transverse line applied each one-hundredth second.

The common origin for the two recording systems was selected at the instant the front bumper of the car contacted the barrier. A probe was mounted so that it extended through the radiator flush with the front bumper. A slight axial movement of this probe actuated a switch connected to one channel of the oscillograph. The broad end of the probe was clearly visible to the high-speed camera so that the instant of contact was easily identified.

Instrumentation for the physiological aspects of a collision is most difficult. Obviously, physiological aspects can best be evaluated through the use of human subjects but there are, of course, considerable limitations here. The use of dummies has enabled many human engineering problems to be evaluated. For most collision conditions involving accelerations or decelerations in excess of approximately 5g, the kinematic behaviour of the dummy corresponds reasonably well with that of the human subject.

Virtually all types of vehicle collisions could occur without injuries to drivers and passengers if it were practicable to build on to the car a sufficient amount of structure of suitable strength. An opposite extreme of the protection afforded to the motorist by such a hypothetical car structure is typified by the motor-cycle. For most collisions, the motor-cycle provides negligible protection because the motorist is outside the structure. Obviously, a reasonably satisfactory compromise lies somewhere between these two extremes.

An interesting comparison was made which showed the similarity of deceleration patterns for an automobile-barrier collision, an aircraft-barrier collision and a simulated collision by a linear decelerator. Perhaps the most striking similarity is that the peak deceleration of the subject's chest, regardless of the kind of vehicle he rides in, always exceeds the peak deceleration of the intact portions of the body of the vehicle. Within the limits of practical design, this condition will probably always exist, even when the passenger is effectively restrained. In addition to the yield provided by the limited degree of freedom necessary for comfort within a restraining device, other factors contributing to the excessive deceleration of the subject are:

1. Plastic and elastic deformations of the anchorage, hardware and webbing of the restraining device.
2. A degree of yielding of the unrestrained portions of the subject, such as flailing of his limbs and movements of his upper torso and head.
3. Elastic deformation of the subject in the areas of the body subjected to the restraining pressures.

These factors also account for the delayed onset of deceleration of the subject relative to the vehicle in which he is riding. A third factor is the characteristically abrupt rate of onset of deceleration for the subject's chest as the deceleration increases to a peak. This initial peaking is followed by a rather abrupt, though brief, partial recovery, which leads to a second abrupt increase in deceleration followed again by a partial recovery which, after its initial phase, decreases at a moderate rate to zero.

For the purpose of evaluating the effectiveness of several configurations of restraining devices, three collisions with a fixed barrier were conducted, each with approximately the same impact conditions. In these three experimental runs, the speeds did not differ by more than 4·4 m.p.h. and the cars used were the same make, model and year. Each separately struck the same fixed barrier by direct impact. The differences between the curves of Fig. 1 show the difficulty encountered in attempting to hold constant all but one of the variables of a collision, for the purpose of studying the effect of that variable for a given collision. A closer examination of the specific values of these curves shows that they correlate reasonably well, considering they represent collision decelerations.

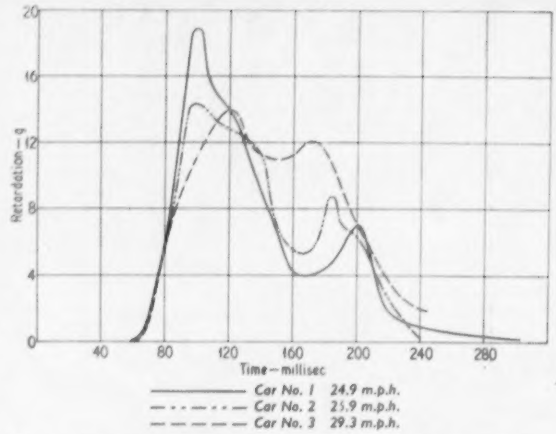


Fig. 1. Retardation characteristics of three cars of the same type colliding with a fixed barrier.

Collision deceleration is seldom uni-directional: rotational as well as translational accelerations generally develop. Even direct impacts with fixed objects having large flat surfaces involve, in addition to longitudinal deceleration, vertical accelerations and decelerations. The extent to which accelerations other than longitudinal are present is important since they also have an influence on personal injuries. Initially, and during most of the collision, the decelerations are predominantly longitudinal, but towards the end of the impact a relatively strong vertical influence is evident. The sequence of strong longitudinal decelerations followed by smaller but increasing vertical accelerations may be fortuitous, since the motorist is not likely to be dislocated vertically before the high longitudinal decelerative forces are applied. This factor requires consideration when contemplating the use of certain restraining devices.

A good example of the complex nature of automobile collisions is provided by the rear-end type. Initially, the rear car is abruptly decelerated. On the other hand, the rate of acceleration for the stationary vehicle is initially relatively gradual, but the injury potential for the occupants of the struck car for speeds up to at least 20 m.p.h. is many times that for the motorists in the striking car. The presence of a headrest extension on the seat squab would allow the motorist to benefit from the slower rate of onset of acceleration. An unsupported head develops a velocity differential with respect to the shoulders and injury due to whip-lash effect is sustained.

The Materials and Research Department, Division of Highways, State of California, has conducted many automobile impact tests for the purpose of evaluating different curb and bridge rail configurations. In three such tests to determine the force systems acting on the motorist during these collisions, the University of California co-operated. Quantitative information obtained is presented in Table II. These moderately high-speed oblique impacts are charaterized by relatively low longitudinal decelerations that last approximately 100 milliseconds and are accompanied by very high lateral decelerations. The lateral forces last for no more than 20 milliseconds. When these lateral decelerations are of very short duration and also when the car doors

TABLE II. OBLIQUE IMPACT DATA

Vehicle	1949 Ford 2-dr. sed.	1949 Ford 4-dr. sed.	1946 Buick 4-dr. sed.
Barrier configuration struck	Bridge rail and curb	Bridge rail and curb	12-in curb type B
Impact velocity, by micromotion analysis ..	50 m.p.h.	40 m.p.h.	41 m.p.h.
Angle of impact, measured at site	20 deg	30 deg	18 deg
Peak longitudinal g, micromotion Analysis	17g	10g	1g
Average lateral g, micromotion analysis and calculations	100g for 8 milliseconds*	90g for 20 milliseconds	80g for 20 milliseconds
Remarks	Car struck bridge railing obliquely at 50 m.p.h. and careered to parallel railing at 38 m.p.h.	Right car door sprung open and closed again after impact. Deflection on impact similar to 2-dr. sedan.	Car hurled over curb with 11 deg change in direction

* *Effect of force not too significant because of extermely short duration.*

remain closed, they tend to be more of a hazard in disorienting the motorist than in directly producing injury. The danger of disorientation, of course, is that the driver may lose control of the vehicle.

High-speed photography has shown that during these collisions the doors opened and closed so quickly that the action escaped the notice of trained observers. For some oblique impacts, this brief period is nevertheless sufficient for the driver to be ejected through the door. The recent improvements of door lock mechanisms made by several manufacturers should correct or at least greatly improve this situation.

Restraining devices for drivers

The dynamics of the human body during a collision were evaluated for five conditions of restraint. Four of the collisions were between a car occupied by dummies and a fixed barrier at 25 m.p.h., while the fifth was a 20 m.p.h. rear-end collision between a stationary car occupied by a dummy and one driven by a human subject. The results of this latter test have been used as the basis for estimating body dynamics for a collision with a fixed object at 25 m.p.h. Quantitative data for three conditions of restraint are given in Table III.

It should be apparent that, provided the restraining devices are properly designed, the configuration that most effectively prevents the body from striking the car's interior during identical collision conditions will be that which gives the best force-time performance. Belt tensiometers provide a force-time history for the load conditions to which the belts were subjected. Tensiometers were used in pairs for the chest and lap belts, one near each anchorage of the belt, in order to detect differential loadings due to lateral accelaration components. The fact that average peak forces for all three belt configurations were approximately the same must be regarded as coincidental even though the cars were crashed at approximately the same speeds. Differences in deceleration rate, and belt configurations and dummy weight, 170 and 200 lb dummies were employed, explain why this similarity in average peak force must be considered coincidental.

In Fig. 2 the curves show the close correspondence of data for the shoulder-loop belt, since the two tensiometers, placed in series, were measuring the same loading at the same point. Also significant is the fact that the rate of onset and subsequent reduction of force for the shoulder belt is relatively gradual. Figs. 3 and 4 show tensiometer readings for chest and lap belts during the same collision. The tensiometers on the left side, for both dummies in the front seat, gave

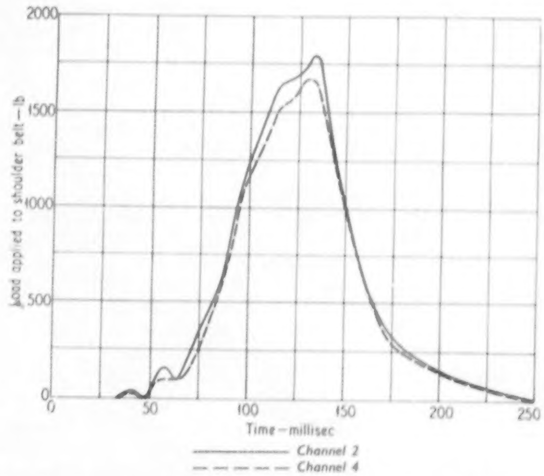


Fig. 2. Force-time relationship for the shoulders of the occupants of car No. 2.

lower readings than those on the right. This indicates that frame failure on the left was more extensive than on the right.

Each belt configuration, *per se*, is capable of effectively restraining the body against the decelerative forces of this collision. Additionally, however, it is important to point out that the effectiveness of each configuration is a function of the layout around the front seats; that is, the extent to which the spatial arrangement precludes the possibility of occupants striking against forward interior surfaces. The superiority of the shoulder and chest belt restraints over the lap belt restraint can be seen by comparing the areas under the curves of Figs. 2, 3 and 4. Conjecture arises, of course, as to the force-intensity level at which each configuration becomes an injury-producing mechanism by virtue of the force concentrations or distributions it produces on the body. Physiological evaluation of each configuration should provide the answer. No attempt was made to include this factor in Table III, because no tests have been conducted to determine these force tolerance levels.

Other restraining devices

Anything that adequately provides support for the head and neck against the forces of a rear-end collision should be recognized as a restraint. The diagnostically difficult injury pattern identified with the low-speed rear-end collision is discussed in a separate study. The medical profession refers

TABLE III. PERFORMANCE OF THREE BELT CONFIGURATIONS

Configuration on restraint	Peak force, lb	Duration belt stress, sec	Force time, units	Relative restraining, effectiveness*	Remarks
Shoulder Loop	1,735	0·143	1,550	100	Shoulder belt dissipates a greater amount of body crash energy than the other two belts, without increasing the peak stress to the body. It accomplishes this gain, for a single restraint, while simultaneously giving maximum protection to the most vital parts of the anatomy, the head and trunk.
Chest	1,735	0·105	1,150	75	Chest belt is less effective as a restraint because it allows more of the body's energy to be absorbed by striking the car interior.
Lap	1,725	0·057	750†	57	Lap belt is the least efficient restraining device of the three being compared for front seat occupancy and for the front-end impact situation. It allows the head and upper torso to strike the forward surfaces of car interior. Energy is then absorbed from the most vital parts of the anatomy by injury producing mechanisms.

* *The area under the force-time curves given in "units" by this table provides an index of the relative restraining effectiveness of each configuration. For ease of comparison, these values are divided by a constant to make the most efficient equal to* 100.

† *This value must be corrected by the factor* 200/170 *to account for weight differences of dummies before determining the relative restraining effectiveness of the lap belt.*

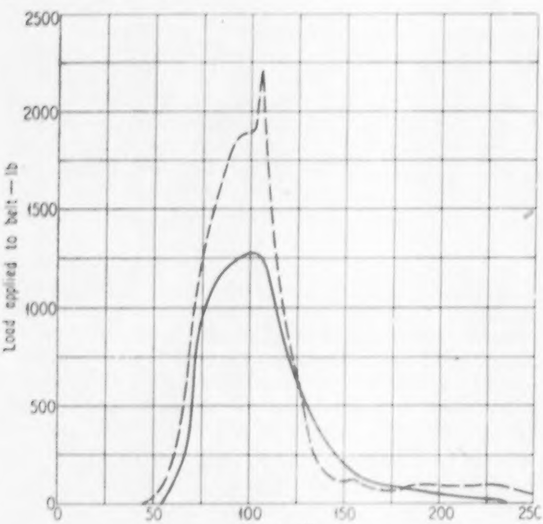


Fig. 3. Chest belt force-time relationship for car No. 3.

to this type of injury as "whip-lash injury of the neck". In a series of rear-end collisions at speeds up to 20 m.p.h. the force system acting on the driver's head was determined. It was found that the magnitude of the force applied to the subject's neck did not necessarily correlate with the impacting velocity. For example, in a comparison between a 10 and a 20 m.p.h. impact, using a dummy subject in each, it was found that the force delivered to the head was larger for the 10-m.p.h. impact. It is recognized, of course, that the height and strength of the seat back as well as the collapse characteristics for the contacting sections of the cars are variables that cause the forces applied to the motorist during a rear-end collision to be unpredictable. In fact, it is this aspect of the problem that leads to confusion.

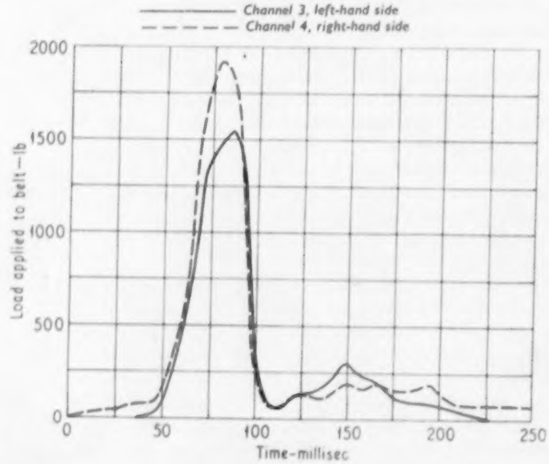
It was found that in a rear-end collision, the cars crush together about 18in before the struck car begins to accelerate sufficiently to affect the driver. Due to the acceleration, the driver's back is then pressed with increasing force against the seat, which flexes backwards until it strongly resists further bending. At this stage, the shoulders are supported against further rearward movement but the head and neck continue to be forced rearward to develop the whiplash injury. An analogous but corrected situation is provided by the carrier-based military aircraft: the pilot is provided with a headrest that protects him from receiving whiplash injuries of the neck during catapult launching of his aircraft. This head support is designed so that it does not impair the range of vision to the rear and sides.

Basic engineering information derived from tests

In rear-end collisions at 20 m.p.h., the changes in velocity in relation to time after the two cars come into contact are given in the upper portion of Fig. 5. The graph is self-explanatory but it should be noted that following the instant of maximum car deformation, that is, at 145 milliseconds, the front car still gains additional velocity and the rear car continues to lose velocity, because of the restitutional forces of the cars. This process takes 525 milliseconds and it is completed when the cars separate.

Much of the collapse of car structures that occurs during collisions is not evident following the collision. This fact is presented graphically in the lower portion of Fig. 5. As

Fig. 4. Lap belt force-time relationship for car No. 3.



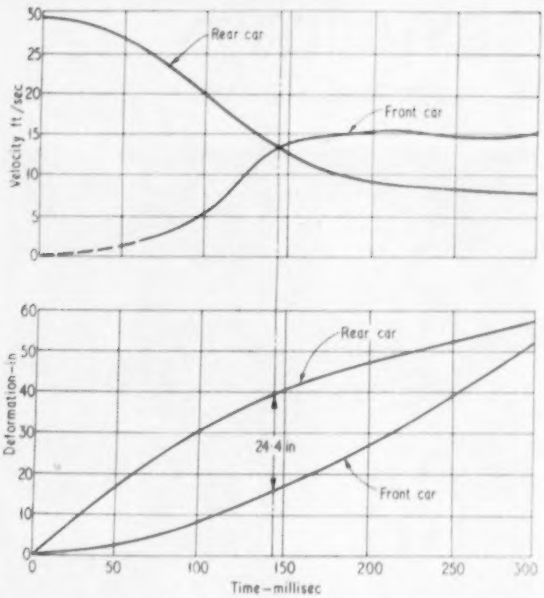


Fig. 5. Velocity and deformation patterns for two cars when one initially moving at 29 ft/sec, ran into the back of the other, which was stationary. The cars broke apart 670 millisec after the instant of first contact.

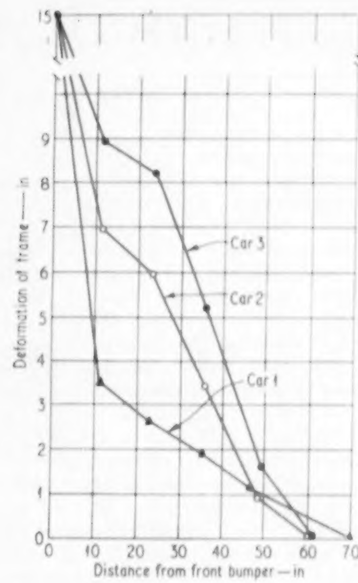


Fig. 6. The frame deformation patterns obtained in collisions between cars and barriers. From these, it can be seen that there is reasonable correlation between the deformations obtained with the second and third cars.

the cars crush together, a time is reached when they have the same velocity. For example, in a 20 m.p.h. rear-end impact, both cars have the same velocity 145 milliseconds after they contacted each other. At this instant the cars have reached the point of maximum deformation. This is 24·4in for a 20 m.p.h. collision, of which the permanent deformations for the front and rear cars were 5·2 and 6·1in respectively. Thus, the total plastic deformation, was 11·3 in and the total elastic deformation 13·1in.

A 7 m.p.h. collision caused a 1·2in permanent deformation of the front car, but none on the rear car. In contrast, for the 20 m.p.h. impact, the front car received 0·9in less permanent deformation than the rear car. For the 10 and 20 m.p.h. collisions, the rear of the front car did not deform uniformly. Adequate information for structural modification of the rear ends of cars to improve their performance during a rear-end collision cannot be properly derived from a single series of tests.

For impact tests, an 8 ft high, 14 ft wide barrier was constructed of large diameter poles; these were backed by suitable cross members and braces as well as by tons of earth. This type of impact imposes a more rigorous test of the protective qualities of motorist restraint devices than would generally be encountered in a car-to-car head on collision. In such collisions there is mutual penetration and, consequently, a lower deceleration rate than with the car-barrier impact, where one of the two colliding objects is essentially, to all practical intents and purposes, non-yielding and non-penetrable.

The mechanism of collapse of a structure during collision is of interest to the engineer. A knowledge of the order and magnitude of deformation of each section of the structure provides a basis for evaluating the efficiency of the total structure. A system was developed by the Institute of Transportation and Traffic Engineering for instrumenting each 6in section of the front of the car frame back to a point approximately in line with the rear edge of the front wheel. It was necessary for this system to provide accurate instrumentation for points on the structure that the front wheel obscured from view. This was accomplished by welding ¼in steel drill rods to the frame at these points in such a manner that they were nearly flat against the frame, and pointed towards the rear of the car. A checkered target was painted on to a 3¼ by 3¼ by $\frac{1}{16}$in plate welded to the unsecured end of each rod.

The timed-displacement of these checkered flags as the car frame decelerated and deformed was photographed by high-speed cameras. Since the metal flags were relatively weightless, and the rods were loaded essentially in an axial manner, it is reasonable to suppose that the errors of measurement for the system were low. However, a control for this instrumentation was introduced for evaluating the error associated with deceleration flag measurements.

One method of obtaining useful engineering information from a collision is to measure specific car frame positions before and after impact, in order to evaluate the location and magnitude of deformations. In the tests, positions on each side of the car frame were marked with metal screws at points approximately 1, 2, 3, 4, 5 and 7 ft back from the front edge of the bumper. The distances between these points were measured by projecting them on to a horizontal plane both before and after the collision. These distances, of course, represent the permanent deformation and are not necessarily related to the elastic deformations that occur during the actual collision.

Three cars of the same make, model and year were crashed independently into the same rigid barrier at approximately the same speeds. Cars 2 and 3 may differ slightly from car 1 because in the latter, the two front seats were mounted on a pair of specially instrumented 4in × 8in steel I-beams. The gross weights of the vehicles were 3,077, 3,240 and 3,380 lb, the two heavier vehicles carried additional dummies weighing 200 lb each. A comparison of the deformation patterns for these three nearly identical vehicles crashed under essentially the same conditions is given in Fig. 6, from which it can be seen that there is reasonable correlation between cars 2 and 3. The removal of the two left side doors and the alteration of the weight and balance of car 1 may account for its significantly different deformation pattern. Although cars which appeared not to have been involved in an accident were selected, their history may also have had a bearing on this divergence.

MACHINE TOOL EXHIBITION

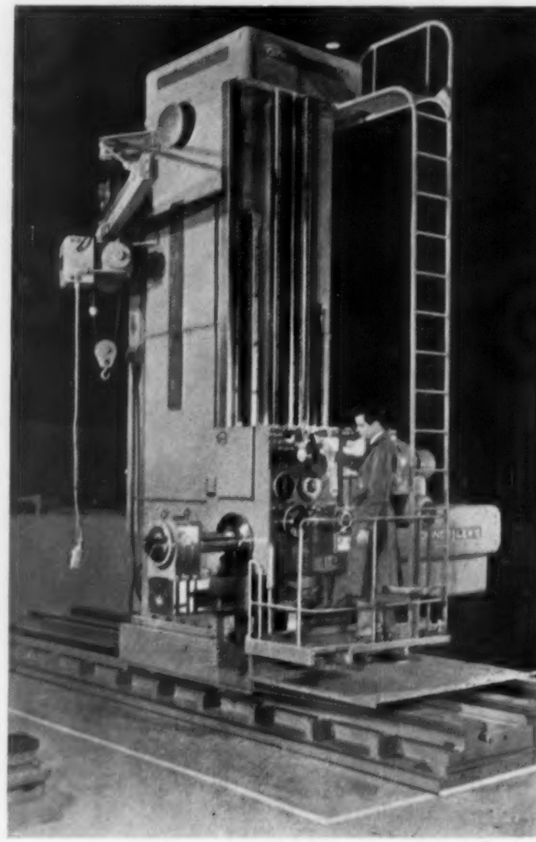
Notes on Developments that will be on Show at Olympia this Year

EVERY fourth year the Machine Tool Trades Association organizes an exhibition that is of great interest and value to everybody engaged in the metal working industries, since machine tools of every type will be on display. At this exhibition users have the opportunity to compare the products of the British machine tool industries with those of the industries on the Continent of Europe and in the United States of America. The exhibition this year is to be held at Olympia, London, from 22nd June to 6th July.

More than 3,000 machine tools, ranging from heavy presses and large lathes to small precision machines for the watchmaking and instrument industries will be on display. With such a large number of exhibits, it is manifestly impossible to give anything approaching a comprehensive review, even if it were confined to machines of direct interest to the automobile and ancillary industries. In these notes, therefore, it must suffice to summarise the lines along which machine tools have developed since the previous exhibition in 1952 and to illustrate the developments through brief descriptions of various machines that will be on display.

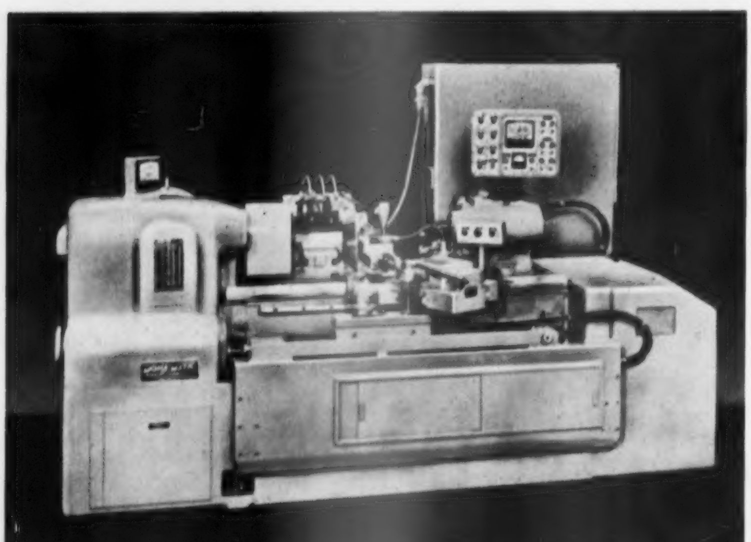
So far as the automobile industry is concerned, there is no doubt that during recent years the most significant machine tool developments have been the automatic transfer machines. Such machines are, of course, designed and constructed to deal with a single specific component; therefore, it is not to be expected that the exhibits will do full justice to the developments in this type of machine. There will, however, be ample opportunity to study all other developments.

An outstanding feature of the exhibition will be the wide use of electronic controls for several different purposes. There is, for example, the electronic control of spindle speed so that the optimum surface cutting speed can be maintained automatically on different diameters or on a steep taper. However, it is probable that the electronic devices which will arouse the keenest interest will be those used in connection with some form of feed back system, magnetic tape or



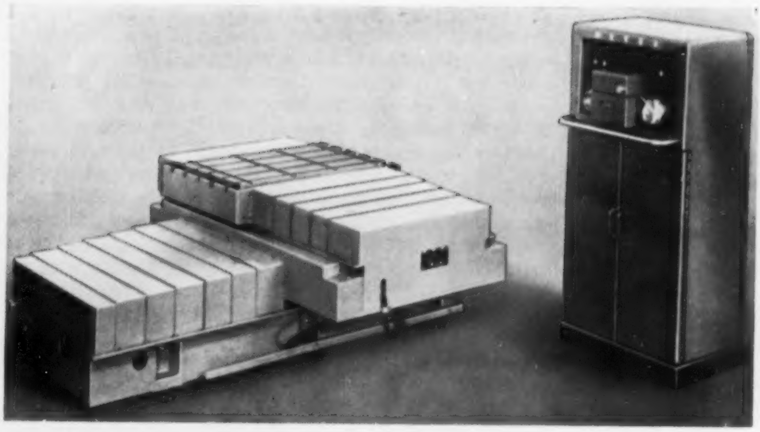
(Above) Giddings and Lewis boring, drilling, milling and die-sinking machine equipped with British Thomson-Houston three-dimensional electronic control

Rockwell Machine Tool Co. Ltd.



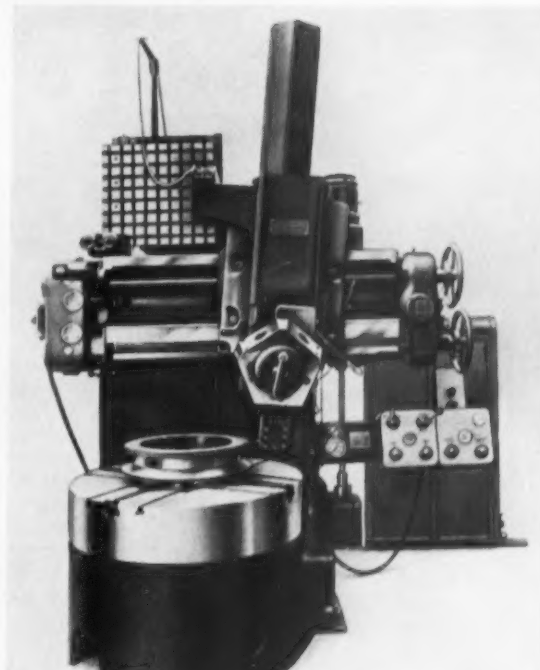
(Left) This Monarch Mono-Matic lathe incorporates electronic control

Rockwell Machine Tool Co. Ltd.



(Left) The Arter Jigmatic arrangement of work table and slides is controlled by punched tape for use on radial drills
Burton Griffiths and Co. Ltd.

(Below) Webster and Bennett boring and turning machine with built-in electronic profile turning equipment
Wickman Limited



punched card, to control all the machine movements. There will be several machines on which this type of control in one form or another is employed. Perhaps one of the greatest potentialities of electronics applied to machine tools will be for controlling dimensions within pre-set tolerances. In other words, the work will be inspected electronically while machining is in progress so that the machine is stopped automatically when either of the pre-set limits is reached.

Conventional machines are, of course, the staple of all machine tool industries, and as such they will represent by far the greatest number of exhibits. In many cases they may appear to differ little, if at all, from the machines shown four years ago, but in general they will be found to incorporate improvements and refinements that appreciably increase efficiency in some way or another.

In the final analysis, every machine tool development has one aim—improved efficiency, which may be obtained in several different ways. For instance, during the period since the previous exhibition, there have been considerable advances in the automatic loading and unloading of machines to give shorter total cycle times with reduced operational fatigue. Many machines have been made more rigid and have more powerful driving motors than the machines they supersede; this means that full advantage can be taken of the cutting tool properties. In fact, it may be said that many machines could operate at even higher cutting speeds and with heavier cuts than are possible with the cutting tools now available. Here it may be said that longer life between regrinds and greater total life for expendable small tools are matters of greater moment to the automobile industry than is a reduced cycle time through higher cutting speeds.

Electronic controls

Two machines with different forms of electronic control will be exhibited by Rockwell Machine Tool Co. Ltd. One is a Giddings and Lewis boring, drilling, milling and die-sinking machine equipped with British Thompson-Houston three dimensional tracer equipment. An important feature of this machine is its versatility. It can be used as a standard boring, drilling and milling machine, but is in addition a duplicating machine capable of carrying out all the operations necessary for die milling and 360 deg profiling work.

The British Thomson-Houston three-dimensional system gives simultaneous automatic control of the saddle and headstock, or saddle and table, for die milling. Alternatively, the table and headstock may be automatically controlled to give 360 deg profiling. A single tracing head, sensitive to deflections in all three directions, is used for copying work. The three feed motions are driven by independent d.c. motors, each powered by its own d.c. generator on the "Ward-Leonard" principle. These generators are regulated by an electronic control that responds to signals developed in variable inductance coils in the tracer head. The individual feed rates are varied by adjusting the speeds of the d.c. motors.

In die milling operations the stepless feed of the tool over the contour of the work remains constant irrespective of the steepness of the contour. Adjustable limit switches automatically reverse the feed at the completion of each pass, simultaneously setting the next cut. In profiling, 360 deg duplication of external and internal forms can be effected automatically.

A second machine with a form of electronic control to be shown by Rockwell Machine Tool Co. Ltd. is a Monarch Mona-Matic, which is being shown for the first time in this country. This machine has a constant cutting speed, with

a fully automatic four-cut work cycle. The multi-cut device is an arrangement that provides for as many as four completely automatic passes of the tool over the workpiece. The first and second passes are roughing cuts controlled by an air-actuated indexing stop unit working in conjunction with an air gauge tracer stylus. The third cut is a semi-finish pass controlled by a template, while the fourth and final pass, also template controlled, is performed when the template holder is automatically indexed to bring the finish template into operation.

The multi-cycle programmer fitted to this machine is a unit comprising a cam drum with up to 24 cams. This drum is arranged to index 1/20th of a revolution at a time. The cams control a series of switches, which in turn control the feeds, the length of cut, the operation of the rear slide, etc. Power for the front carriage feed and rapid traverse is supplied by an electronically controlled motor housed in the gearbox compartment. The constant cutting speed headstock allows the correct cutting speed to be maintained irrespective of changes in diameter. The constant surface cutting speed provides a 4 : 1 ratio and is powered by a 25 h.p. variable speed motor controlled by a conversion unit and electronic control.

Wickman Limited, Coventry, will be showing a Webster and Bennett boring and turning machine with built-in electronic profile turning equipment. This equipment is designed as an integral part of the machine and not as an attachment. Because of this, the machine may be used at will either as a standard or as a tracing machine. Change-over from one to the other is effected by means of a simple push-button control.

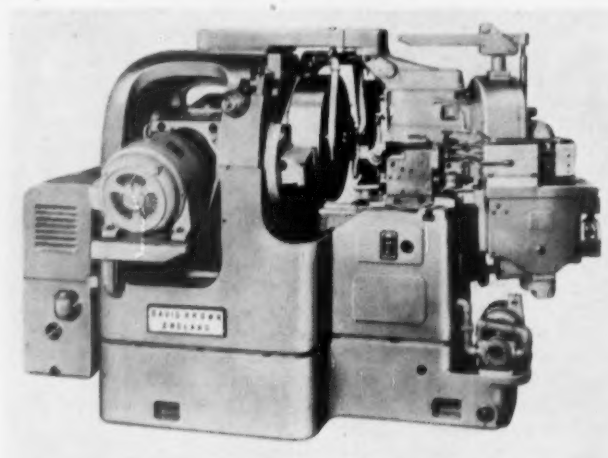
When the machine is used for tracing, the direction of profiling and feed are first set, and after the initiation of the profiling cycle the stylus moves in towards the template. When the stylus contacts the template, the output signal from the tracer head passes through an analyser and calls for an increased generator output, and hence for movement of the appropriate motorized slide.

As soon as the stylus deflection reaches a predetermined figure, a relay is energized, and the output of a second generator causes the appropriate motorized slide to move the stylus, and hence the tool, tangential to the profile that is being followed. At this point the complex signal from the head is analysed and split into two electrical signals equivalent to the mechanical displacements in the two axes. These two signals are compared with a reference, and the two resultant signals provide the control signals for adjusting the cross and vertical slides according to the change in the output from the tracer head. The electronic profiling equipment on this machine is supplied by Lancashire

No. 7 Hydrax hobbing machine

B.11 spiral bevel and hypoid gear rougher

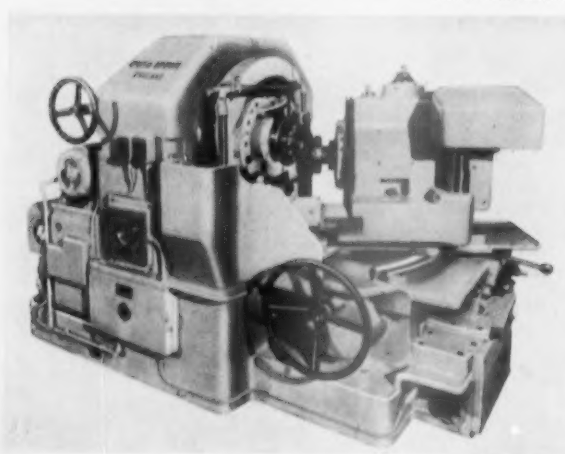
David Brown Machine Tool Division



B.16 spiral bevel and hypoid gear generator

S6H fully automatic gear shaving machine

David Brown Machine Tool Division

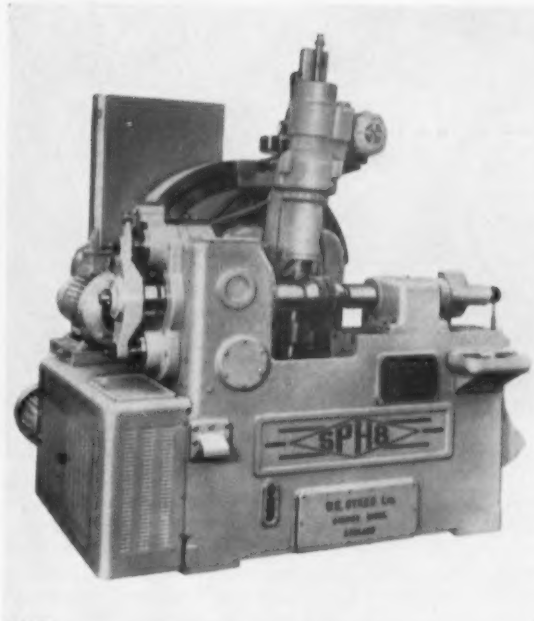


Dynamo Electronic Products Ltd.

A particularly interesting and significant development will be exhibited by Ferranti Ltd. This is a milling machine producing three-dimensional parts from the solid under the control of a magnetic tape prepared by a special digital computer. It will demonstrate that a combination of the most advanced electronic techniques and of mechanical engineering now enables simple or complex components to be machined entirely automatically to any desired degree of accuracy without the use of jigs, models or cams. The most interesting part of the control system is the digital measuring device, which is capable of a degree of accuracy that matches the capabilities of the most precise machine tool. It is, at the same time, simple and free from mechanical wear. The system as a whole is applicable to any machining operation, both when continuous control of tool position is required, as in milling and turning; or when co-ordinate positioning is called for.

Another punched tape controlled machine, the Jigmatic developed by the Arter Grinding Co. of the U.S.A., will be exhibited by Burton, Griffiths and Co. Ltd. The Jigmatic consists of a rectangular table, capacity 20in × 30in, mounted on a compound slide that has two sets of ways at 90 deg to each other. This table can be mounted on most types of 4 ft and larger radial drills. The table is controlled by a tape reader housed in a cabinet, which may be located in any convenient position relative to the table, since it is connected to the table only by electric cables. The punched tape is prepared on a template type hand punch from the engineering drawings. It is not necessary to code or convert this information in any way before punching. All hole locations are referenced from X and Y co-ordinate axes, and it is only necessary that the workpiece be located on the Jigmatic table in proper relation to these axes. As many as

VS.4A fine pitch gear shaving machine
W. E. Sykes Ltd.



SPH high production hobbing machine
W. E. Sykes Ltd.

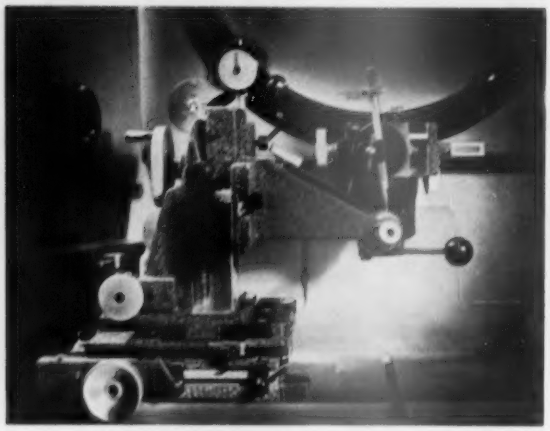
200 hole locations can be punched on one length of tape. The tape is easily loaded into the reader, and there is no need to rewind upon completion of a piece. As the tape is not rewound, there is no danger that the operator may load it in to the reader in an incorrect position.

Two standard electric motors drive the table through a system of gears and clutches. The table is positioned by two precision ground lead screws, and the drive and control mechanism incorporates an automatic mechanism to provide final positioning in only one direction, regardless of the original direction of table travel. When in position, the slides are locked by means of an electromagnetic brake.

In operation, the tape is first placed on the locating pins, then fed through the slot in the reading head and on to the wind-up reel where the tape end is secured by a spring clamp. The loading knob is rotated from "load" to "run" and the "tape start" button is pressed. The tape then traverses through the head until the first set of punched holes is in reading position. At this point the operator can press the "position" button, which causes the slides to move to the position indicated by the punched holes. When this position is reached a red "positioning" light goes out and a green "in position" light is illuminated to signify that the table is in position and locked. The tape then automatically moves in to position to read the next hole location. When the operation is completed on the first hole, the operator merely has to press the "position" button to traverse the table to the second hole.

Gear cutting, finishing and testing equipment

David Brown Machine Tool Division will be showing, among other machines, seven that are completely new and one, the No. 14 Hydrax, which although introduced in 1954 will be shown for the first time at a public exhibition. The No. 14 Hydrax high speed production hobber quickly earned a high reputation, and the Company now introduces a smaller machine, the No. 7 Hydrax for rapid automatic production of spur and helical gears up to 7½in diameter, 4 D.P. As with the older machine, hob traverse is along the gear helix, but on the new machine the axis of the gear in the cutting position is horizontal.



OGP optical gear analyser
Gaston E. Marbaix Ltd.

After the gear blank has been centred and clamped hydraulically, operation of a single push button sets in motion the fully automatic cutting cycle of eight operations, ending with a finished gear ready for removal and the machine switched off. The machine can also be arranged for plunge feed of the hob to correct depth before traversing across the face of the blank. This effects a considerable reduction in hobbing time.

One of the principal features of the Hydrax machines is the simplified and very accurate method of cutting helical gears. No differential mechanism, lead screw or lead cams are employed. Instead, the direction of the hob traverse is simply inclined to the work at the helix angle of the gear to be cut. This not only simplifies setting-up procedure, but also provides a limited automatic hob shift that reduces hob traverse and considerably shortens cutting times.

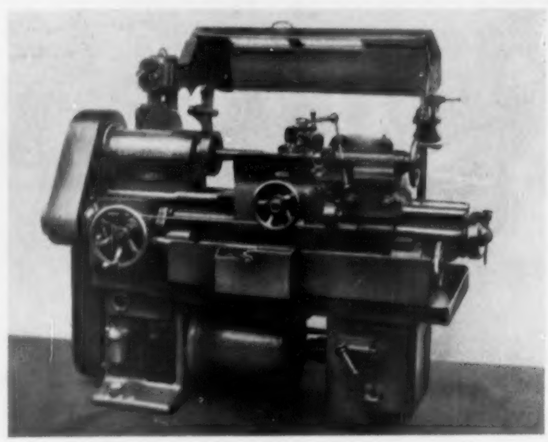
It is of great interest to automobile engineers that David Brown Machine Tool Division has, after intensive research over a period of years, developed a range of spiral bevel and hypoid gear machines of types that hitherto have been available only from the United States of America. The machines to be shown are the B.11 roughing machine, the B.16 generator and the B.17 testing machine. A finishing machine and a tester and lapper are also available but will not be exhibited.

The B.11 roughing machine is suitable for highspeed production of spiral bevel, zero spiral angle and hypoid gears up to 13in diameter, 3.5 D.P. It is fully automatic, with the cutting cycle controlled by a single push button. The cutting action on this machine is not based on the generating principle. Instead, gashes are cut by means of simple depth feed of the cutter into the workpiece.

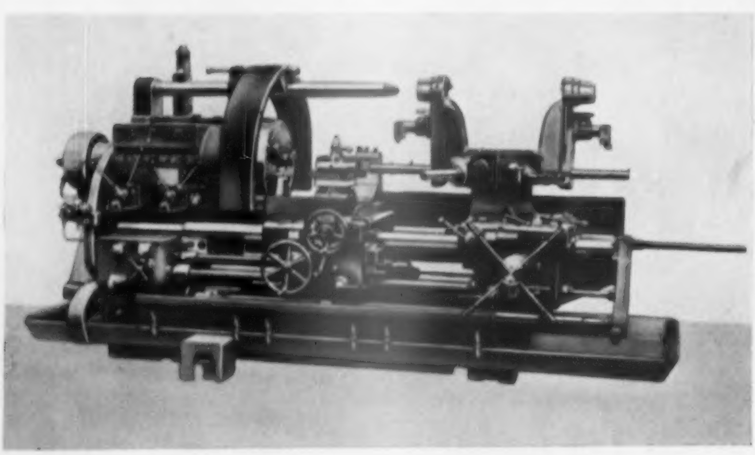
The B.16 generator is a universal machine suitable for both batch and quantity production of spiral bevel, zero spiral angle and hypoid gears up to 18in diameter, 2·5 D.P. After the initial setting, the cutting cycle is fully automatic. The gear blank is fed to full depth with the cutter at the lowest point of generating roll, and both flanks are generated by rolling with the cutter. The blank is then withdrawn and indexed one tooth space during the down-roll of the cutter.

Two new David Brown automatic gear shaving machines will also be exhibited. They are designed for shaving spur and helical gears and involute splines by the radial loading method, using the crossed axes principle. A feature of these machines is that they are capable of three different forms of shaving technique; namely, the axial, the oblique and the tangential traverse methods. These machines are completely automatic in operation and are designed for automatic loading.

W. E. Sykes Ltd. will also be exhibiting new high production hobbing and gear shaving machines. The new hobbing machine, the SPH.8, has been designed specifically for fast and accurate working. It is particularly suitable when long runs, with minimum maintenance, are necessary. Its maximum capacity is 13in dia, 4 D.P. An automatic hob-shift ensures that wear takes evenly across the entire width of the hob, thus giving very long tool life. The mechanism can be adjusted to act on completion of each component or the hob can be moved after a predetermined

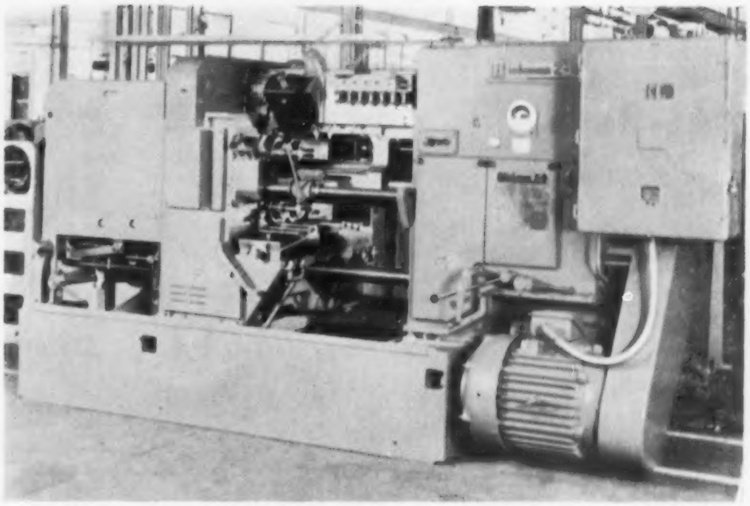


(Above) *Carbijunior copy turning lathe*
Alfred Herbert Ltd.

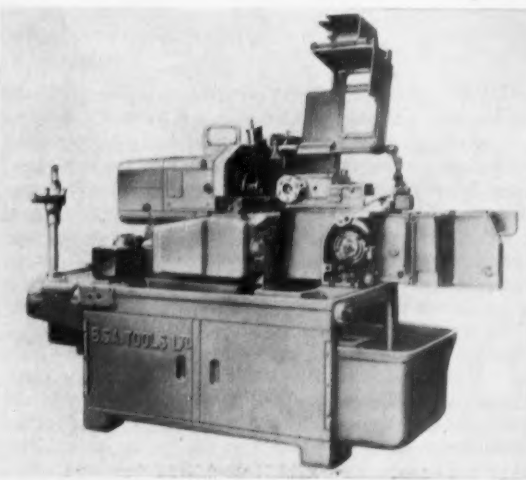


(Left) *No. 9C/30 combination turret lathe for chuck work up to 30in swing*
Alfred Herbert Ltd.

(Right) *Six-spindle automatic bar machine which will be tooled for a complicated component*
Wickmam Limited



68L single spindle automatic screw machine
B.S.A. Tools Ltd.



number of parts. The complete cycle is automatic.

The new fine pitch gear shaving machine, the VS.4A, is for finishing spur and helical gears up to 4in diameter and 1in face width. It works on a principle rather similar to that used for transverse shaving, with the work moving while the rotary shaving tool remains stationary. The tool, instead of the work, is set to the required angle. The finishing cycle is completed in four longitudinal strokes, the work and tool centre distance being progressively reduced after each stroke until the finish size is reached. To reduce cycle time to a minimum, a fast infeed brings the shaving tool and the work into the correct relationship before shaving starts, at which point the normal infeed speed is engaged for the actual cutting. With the exception of loading and unloading, the complete cycle is automatic.

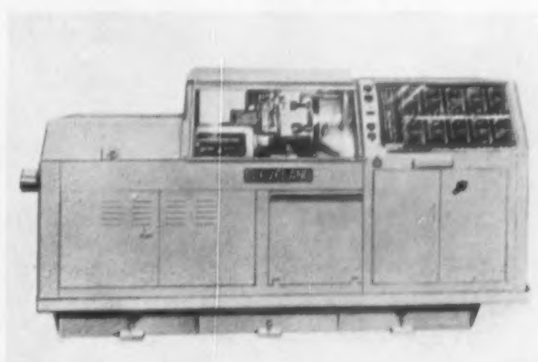
An optical gear analyzer, the OGP, developed by Optical Gaging Products, Inc. of the U.S.A., will be exhibited by Gaston E. Marbaix Ltd. It is designed to analyse the involute spur gear by direct observation of the meshing gear and a fixed rack chart. The gear is viewed as if it were rotating in contact with and at the correct centre distance from the fixed rack on the screen chart. Analysis of the gear is made by observing the running at a magnified projection. The running action is simulated by traversing the staging fixture on which the gear is mounted with one of the gear teeth in contact with a fixed "half rack" pin. This pin is set to coincide with one flank of the rack teeth so that the gear actually functions as it will in operation.

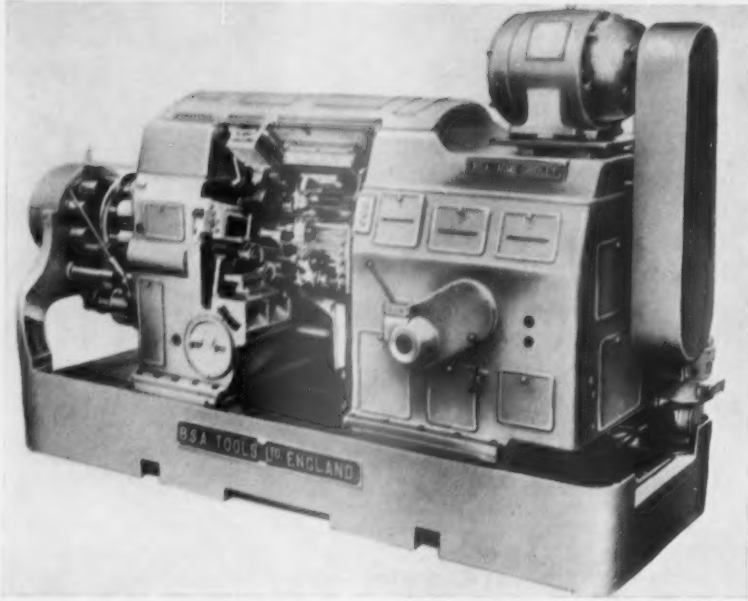
With this instrument form deviations can be quickly identified and measured. In addition, backlash can be measured accurately either as centre distance correction or as clearance between mating teeth. Outside diameter, root diameter and fillet clearance can also be gauged quickly and easily. Taper, crown and symmetry are also easily checked, and one standard gear chart gauge can be used to check all gears of the same pitch and pressure angle regardless of their pitch diameters.

Lathes

It is almost unnecessary to say that Alfred Herbert Ltd. will exhibit a selection of capstan and combination turret lathes, ranging from the No. 0 electro-pneumatic capstan lathe for bar work up to ½in diameter to combination turret lathes such as the new No. 9C/30, which is an extremely powerful machine for chuck work up to 30in swing. This machine has a sliding gear headstock which in conjunction with a two-speed 25/7 h.p. motor provides a range of 32 reversible spindle speeds from 7 to 600 r.p.m. The direction of spindle rotation; start, stop and inch spindle; and start and stop of quick power traverse motor are all controlled by push-buttons conveniently mounted on the headstock face. When selection of a given speed is completed, the gear shift levers are automatically locked in position. The machine

Cleveland 'Dialmatic' single spindle automatic with electronic control for spindle speed and turret tool feed
Selson Machine Tool Company





B.S.A. Acme-Gridley eight-spindle bar automatic
B.S.A. Tools Ltd.

also has an automatic sliding and surfacing saddle with built-in chasing mechanism; reversible power feeds and quick power motion to the turret slide; while the power feeds of the turret slide are independently reversible in relation to those of the saddle.

This Company will also be showing the Herbert Carbi-junior, a small, high speed centre lathe with copy-turning mechanism for the rapid production of shafts up to 3¼in diameter by 22½in long. This machine is basically a centre lathe and can be used as such to produce a single component by the freehand method of turning. If more components are required, the finished shaft is transferred to the master carrier at the rear of the machine bed and used as a model, which will be reproduced by means of the copying mechanism that is built into the machine.

The copying slide is mounted on the machine cross slide in the position normally occupied by the rear tool post. It consists of a lower slide, fixed at an angle to the axis of the machine, and a movable upper slide. A hydraulic cylinder mounted at the rear moves the upper slide as determined by a built-in control valve actuated by a swinging arm carrying an Ardoloy-tipped stylus. The upper slide also carries a tool block which is adjustable at right-angles to the axis of the work. In operation, the tool exactly follows the path taken by the stylus as it is traversed along the model by the longitudinal feed of the saddle. Square shoulders, tapers or any other form that does not involve too high a rate of infeed can be reproduced automatically.

Along with many other interesting machines B.S.A. Tools Ltd. will be exhibiting a new single-spindle automatic screw machine, type 68L. The "L" refers to the shape of the machine which roughly conforms to an "L" in plan, a feature which allows unimpeded access to the tooling area. This design has been achieved by placing the front camshaft to

New automatic sizing internal grinding machine
Churchill Machine Tool Co. Ltd.

No. 1 tool and cutter grinder
Cincinnati Milling Machines Ltd.

one side. The standard machine is arranged to give two speeds—forward and reverse, or both speeds in the same direction—but a four speed gearbox can be supplied to suit customers' requirements.

The six-station turret head is indexed by means of the normal crank and Geneva mechanism, with the locking plunger carried in the base of the slide body. This arrangement has allowed the slide body to be designed to give more clearance to tooling or attachments mounted on the rear cross slide. An important feature of the turret is the straight withdrawal and advance mechanism which is built-in as standard equipment. This mechanism allows the turret to be rapidly retracted and advanced to the same position without indexing. The straight withdrawal mechanism may be operated as often as required and at any point in the machine cycle.

Advanced American practice in single-spindle automatics will be exemplified by two new Cleveland "Dialmatic" machines which will be shown by The Selson Machine Tool Company. On these machines the speeds of both the turret tool feed and the spindle are electronically controlled and can be infinitely varied simply by setting the appropriate dials. There are no turret feed cams and no change gears; the dials are simply set to the optimum feed and spindle speed at which maximum productivity of each of the five tools is obtained.

Multi-spindle automatics

Attention may be drawn to the range of improved multi-spindle automatics, tooled for a variety of jobs, that will be exhibited by Wickman Limited. Until comparatively recently this organisation built only five-spindle machines, but their range now includes four-, six- and eight-spindle machines for bar work up to 3½in capacity and for chuck work up to 9in capacity. Because of their patented auto-setting mechanisms, the original Wickman multi-spindle machines were suitable for small and medium batches as well as for long runs. Improved versions of these auto-setting mechanisms are incorporated in all the new machines.

Many detailed improvements have also been incorporated. The weight and mass in the main castings have been disposed to provide even greater rigidity to meet the demands for higher speeds and heavier cuts, swarf conveyors are designed as integral elements of the machines, and automatic trips in bar feeds and other mechanisms assist the promotion of higher machine utilization as well as to greater safety of operation.

The tooling possibilities of the most recent Wickman bar machine, the 2in—6-spindle, will be displayed in the production of a mild steel component. This workpiece calls for seven external and four internal diameters, a rolled thread behind a shoulder, a rolled exhibition marking, a tapped thread, and facing to length. There are 14 tools and the cycle time is 9·6 seconds.

Another Wickman bar machine is designed to feed bar at two stations. It will be tooled to produce two dissimilar components in mild steel in a cycle time of 3·8 seconds. To demonstrate the diversity of tooling that is possible on Wickman chucking automatics, a six-spindle machine will be shown machining a differential case, for which the set-up comprises a total of 21 tools mounted singly and in combination operating in a cycle time of 50 seconds.

B.S.A. Tools Ltd. will also be showing new multi-spindle automatics, including the B.S.A. Acme-Gridley 1¾in BRB. eight-spindle machine. This is a machine with great production possibilities. Because of its eight spindles it is capable of producing two components of appropriate type per cycle, or by double indexing two different pieces may be produced per cycle. It also allows the tooling to include several operations, such as cross drilling, thread chasing, milling, etc. to get a complete piece in one index, thereby eliminating second operation work.

Grinding machines

There will, of course, be grinding machines for every conceivable type of application. Many will be developments of well-proven designs, but there will also be many completely new machines. For example, The Churchill Machine Tool Co. Ltd. will exhibit a completely new automatic sizing internal grinding machine, model "HMB". This machine can be operated on a double automatic cycle with intermediate truing, or on a single automatic cycle. Which will be used is dependent upon the work to be ground. In either case, sizing is controlled by the setting of the truing diamond, but the essential difference between the two cycles lies in the wheel truing. In a single cycle the truing occurs just before the grinding wheel enters the work, whereas in a double cycle the wheel is trued between the roughing and finishing stages. Change-over from one cycle to the other is quickly and easily made. The double cycle method of operation offers particular advantages when grinding allowances are inconsistent, when stock removal is comparatively large, and when very fine finish and a very high degree of dimensional accuracy of the workpiece are necessary.

Included in the range of machines to be exhibited by Cincinnati Milling Machines Ltd. is their No. 1 tool and cutter grinder, the Company's latest development in this class of machine. It is designed for grinding and reconditioning miscellaneous small tools and cutters, and embodies several design innovations. These include: 360 deg eccentric wheelhead swivel, which gives greater flexibility; reversible motor drive built into the wheelhead, which reduces change-over time from grinding one type of cutter to another; vertical elevating handwheel for the wheelhead, which is accessible from all operating positions; T-shaped bed construction with saddle-supported wheelhead to allow the operator to get in close to the work; and grinding wheel collets with socket screw arrangement that saves wear and tear on the spindle.

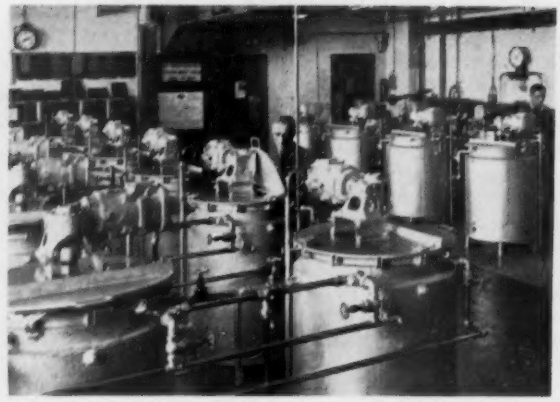
The well-proven Wickman optical profile grinding machine which will be exhibited is still regarded as among the most accurate and universal machines of its kind. On this machine profiles are ground optically from a master drawing 50 times larger than the form to be produced. A microscope and screen projection unit mounted in the final arm of a 50 : 1 pantograph are positioned over the work in precise relationship to the drawn profile, and grinding of the form is carried out by traversing the reciprocating grinding wheel to the centre of the cross hair lines of the graticule in the microscope or screen field.

Several new features have recently been designed to increase the range of applications for this machine. They comprise: a circular grinding attachment that provides means for holding work between centres or in a chuck; an indexing attachment which, when secured to the work table, provides a means of securing press tool die segments and punches that require form grinding in the vertical plane, and indexing for all round working, if required; an end-cutting form tool attachment that provides fully universal adjustment to any angle or combination of angles for grinding small end-cutting tools; and a wheel-forming attachment for dressing radii on the grinding wheel when this is necessary for form blending.

Perforce it has been necessary to confine these notes to certain classes of machines, and even in these classes it has not been possible to make reference to all the interesting machines that will be exhibited. The machines that have been omitted and the types of machines that have not been dealt with at all, will be reviewed in future issues.

Body Finishing

Methods Used for Continuous Flow Production at the Austin Works at Longbridge

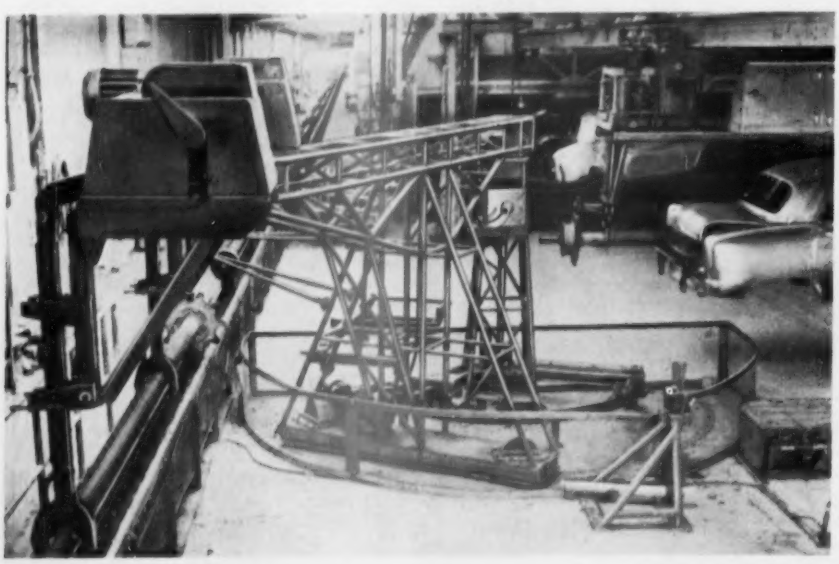


Eighteen duplicated paint mixers are installed in two rooms of the air-conditioned mixing department. Black and eleven colours can be handled

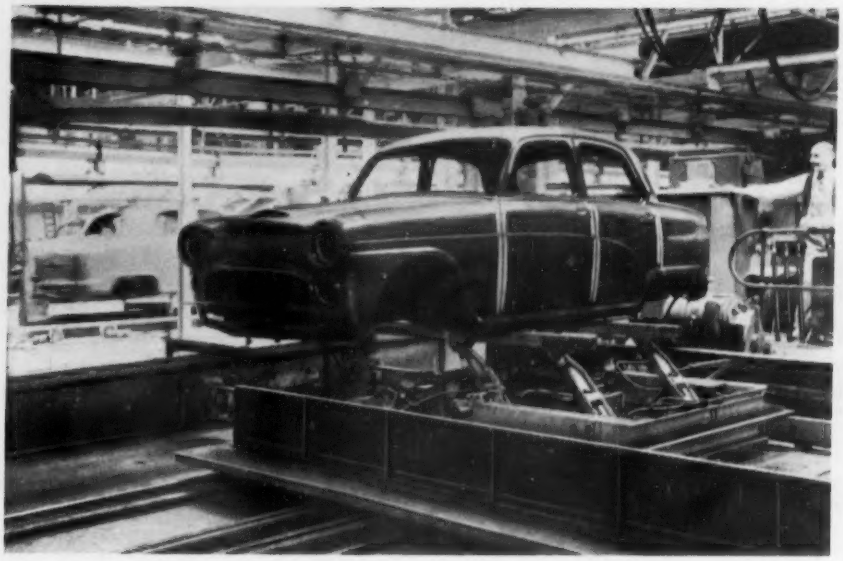
FIFTY years ago, in the first year of its existence, the Austin Motor Co. Ltd. employed 270 workers and produced a total of 120 vehicles. Last year, with about 23,000 people engaged, vehicles were turned out at the rate of 120 per hour. Despite the extent of the Longbridge plant, the largest in the country, and its highly mechanized equipment, facilities do not exist there for building and finishing all the bodies required to maintain such a high rate of production. Approximately 40 per cent of the bodies are produced in the plant and the remainder are brought in from subsidiary plants and from specialist suppliers. Actually, body finishing at Longbridge is organized on a two-shift, 85-hr week, basis and capacity is determined by the two automatic Rotodip plants employed for cleaning and priming the body shells. Each of these gigantic units can, at 100 per cent efficiency, deal with shells at the rate of 25 per hour. As shells for four different vehicles are handled and may require finishing in black or one of eleven different colours, the most careful organization and strict timing of operations is essential in order to maintain correct sequencing and synchronization with engine-building, body-trimming and vehicle-assembly lines. Usually body shells are batched as regards type and colour in accordance with production programming on a weekly schedule, but any colour can be made available at the spray booths at any time should the programme call for individually sequenced colour.

An impression of the magnitude of the operation can be gained from the quantity of finishing materials used. Even for the reduced output of a four-day week the weekly consumption of materials for all purposes, priming, filling, sealing and enamelling is approximately 12,000 gal. For the Rotodip plants alone 2,700 gallons are needed each week. An air-conditioned store holding about 9,000 gal of fillers, sealers and enamels is used to ensure approximately a week's requirements of those materials against any supply contingency.

After the shell has been washed and degreased, the finishing operations may be divided into five categories: phosphating, priming, filling, sealing and enamelling. The first two are single operations but the remaining three involve a plurality of applications, the sealer being added wet-on-wet. Only synthetic resin enamels are used, imparting finish and gloss direct from the spray gun. There is no polishing or other final operation. Film thickness is



At the entry of the Rotodip plant a mechanized boom lifts the spit from the return conveyor and swings it into position to receive the body shell



A primed and stopped shell is transferred from the delivery line to the parallel paint-shop line by a lifting and traversing carriage on a tram

determined by various factors, including viscosity, coverage, flow and build. The viscosity of materials is maintained constant by means of routine checks with the aid of a viscosity cup. Periodically, the thickness of coatings is checked by readings on an Elcometer. This applies not only to the enamel but also to intermediate and priming coats.

In the finishing laboratory, research and development is conducted continuously in order to maintain and improve materials and processes to meet the requirements of a world-wide market. No enamel is used in the plant unless it is passed by laboratory test as conforming to specified standards. Accelerated weathering tests under simulated climatic conditions are made on test panels in an Auswal Weatherometer. The specimens are mounted on a drum which, enclosed in a casing, is rotated at the rate of four revolutions per hour. During each revolution of the drum, each specimen is exposed for 2 min to infra-red radiation, 2 min to ultra-violet radiation, and for 2 min is immersed in a water bath. The test routine is, of course, varied to meet specific requirements but a commonly used standardized test for comparative purposes is operation for twenty-one 8-hr daily periods. The specimens are rested during the intervening night periods. In conjunction with these weathering tests an Evans spectrophotometer with a gloss head attachment is used to compare the gloss of weathered specimens with that of proved and accepted specimens.

Development is directed to the attainment of a finish that in appearance and serviceability is satisfactory under the climatic conditions obtaining in any part of the world. Complete body shells are tested in a humidity chamber for continuous periods of from 500 to 1,000 hr. Comparative humidity tests of small panels finished with materials in supply against similar panels finished with the standard production materials are made in a smaller laboratory chamber.

Finishing materials are mixed and prepared for use throughout the plant in a three-storied building, the ground floor serving as the bulk store and the two upper floors as mixing rooms. Materials are delivered by road in 40-gal drums and on arrival are stacked in nine 4-tiered racks by means of a monorail air-hoist. They are laid horizontally in skidways holding six drums from one side of the racks and withdrawn as required from the other side and placed on a lift for transfer to one of the mixing rooms above. There

An overhead transporter carries the shell on its spit to the mouth of the Rotodip plant where it is automatically loaded on to the conveyor

After passing through the washing and phosphating sections of the Rotodip, the shell is transferred to the priming section. The shell is shown making its first turn into the priming tank

they undergo a pre-mixing operation for from 15 to 30 minutes depending on whether they contain lightly or heavily pigmented material. All drums are equipped with a built-in agitator. The agitator shaft is loosened, an air motor on a ring mount is clamped on the drum end flange, and the drive transmitted directly to the shaft by a pin-and-slot coupling.

Eighteen mixing stations are installed, twelve on the first floor and six on the top floor. Each comprises duplicated 50-gal mixers with individual motor drives, piped and valved so that either can be used alternatively while the other is shut down for cleaning or servicing. Normally, however, the two units are operated in series, one for mixing and thinning and then, after transfer, the other for feeding out to the pipe lines. All pumping is done by rotary pumps except in the case of heavily pigmented enamels and primers for which piston pumps are employed.

In the mixing rooms drums of enamel are transported in a tipping cradle on an air hoist. Appropriate thinners are added from supply systems piped to each mixer, the quantity drawn being indicated on wall-mounted dials. The operator brings each mix to the specified viscosity by checks with a standard viscosity cup. Feed to the spray booths is at a pressure of 60 to 70 lb/in² and against a return pressure of 20 to 35 lb/in² in order to ensure a constant pressure at the spray nozzles. The entire mixing plant, including the store, is air-conditioned and maintained continuously at a constant temperature of 80 deg F. All motors, switchgear, and lighting fixtures are enclosed and fire-proofed. The electrical wiring is enclosed in unburied copper tubing coupled with unions to provide complete sealing.

In the body-building shop, the Rotodip plants are installed across the ends of the parallel press lines and welding lines. The completed body shells are brought into the Rotodip section on a conveyor, lifted off by an electric hoist and loaded on to individual bogies on two floor tracks, each comprising one flat and one channelled rail. While parked on these tracks special clamping fixtures are mounted at each end of the shell; the front one to the radiator bulkhead and the rear one to the lamp orifices. Each fixture is furnished with a quick clamping device to grip the spit on which the body is carried and rotated through the Rotodip.

Spits are returned from the unloading end to the loading end of the Rotodip by a long chain-type conveyor. From this a spit is removed by a special lifting device on the end of a swinging boom. Two arms are lowered, tong-like jaws are engaged over the spit and automatically latched. The spit is then lifted clear, swung through an arc of 90 deg and

On this part of the line the shells are given a wet rub-down after the filler coating has been applied, stoved and cooled

Body shells receiving the final enamel coating in an air-conditioned spray booth. Shells are rotated in counter-balanced cradles. Spray guns delivering a range of different colours are hung on a rack behind each operator

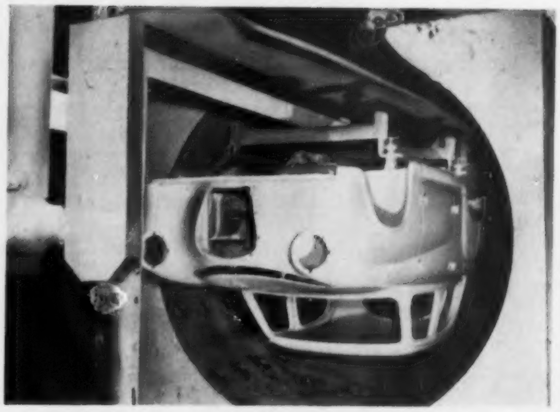
lowered until one end, that fitted with a sprocket, rests in a floor-mounted support. A profiled nose to facilitate entry into the shell is then fitted to the free end of the spit. Meanwhile a shell has been hoisted from its bogie and lowered on to a travelling platform running on a track aligned with the spit and its support. The platform is moved along the track until a supporting slideway is located underneath the free end of the spit, the clamps on the suspension arms are released, the arms are retracted, and the boom returns ready to lift another spit from the conveyor.

While this is occurring, the platform carries the shell, rear foremost, further along the track and threads it horizontally over the spit. The shell end fixtures are manually clamped to the spit with the aid of an air-powered wrench, the profiled nose is removed, and then an overhead transporter lowers suspension arms, similar to those on the swing boom, which automatically engage and latch on to the ends of the spit. Retraction of the suspension arms lifts the shell on the spit clear of the platform and the shell is then transferred laterally to the mouth of the Rotodip. Here it is lowered on to a support frame, the suspension arms are retracted and the transporter is returned to pick up the next shell.

On the end sprockets of the Rotodip conveyor chains are picker arms, moved laterally by means of face cams. These arms move inwardly to engage under the ends of the spit, which is lifted from its support and lowered into forked dogs on the conveyor chains with the spit rollers engaged on the conveyor tracks, and are then swung clear of the chains by the cams. The left-side track only is provided with evenly pitched, laterally projecting, cylindrical studs. As the spit is conveyed through the plant the sprocket is engaged in these studs and the spit is rotated to dip the shell into the various solution tanks and to prevent the formation of flow lines while draining or drying.

In the Rotodip plant, which is arranged in three sections each having a separate conveyor, the shell is twice rotated, as a preliminary, to drop out any litter, loose dirt and welding debris into a pit and then operations are sequenced in the following order:

1. The shell makes 2½ rotations in an alkaline degreasing solution at a temperature 170–180 deg F. Throughout, the spit is just clear of the tank and the shell is lowered into and turned in the fluid with the minimum agitation. Overhead are vertical nozzles spraying continuously over the rotating shell.
2. Cold water rinse. 2½ rotations in tank and vertical sprays.



An enamelled A.30 shell leaving the cold-air cooling tunnel after being stoved for 60 min at 240 deg F

3. Hot water rinse at 130–140 deg F. 2½ rotations in tank and vertical sprays.
4. Phosphating treatment at 160–170 deg F. 2½ rotations in tank and vertical sprays.
5. Hot water rinse at 130–140 deg F. 2½ rotations and vertical sprays.
6. Chromic acid rinse at 160–170 deg F. 2½ rotations, no sprays.

Following this operation the shell is lowered to an intervening pit, transferred to a second, similar conveyor and then raised to the level of the drying oven.

7. Drying off in gas-fired, convection-type tunnel oven at 250–260 deg F.

On leaving the oven the shell is again lowered to a pit and transferred to the third conveyor. This is run at a somewhat slower speed in order to provide rotative conditions during drain-off and stoving after priming to control flow and runs.

8. Priming. The shell is raised from the pit and then lowered to a tank of chocolate-coloured synthetic primer. 2½ rotations, no sprays.
9. After draining, the shell is stoved in a gas-fired oven for 30 min. at 350 deg F.

As it leaves the oven the shell interrupts a light beam and thus sets a time switch to sequence the unloading of the shell and the return of the spit; virtually a reversal of the operations at the loading end. The overhead transporter picks up the spit, lowers it on to the travelling platform and the support fixture, automatically unlatches and retracts the suspension arms and swings clear. The shell clamps are then unfastened and the platform draws the shell off the spit. A swinging boom then picks up the spit and deposits it on the return conveyor.

Although the spit is not immersed in the priming tank it gradually accumulates drip from the shells. Straddling the return conveyor is a fixture on which are mounted four segmental scrapers. These can be air-operated to engage and retract automatically and, as a routine maintenance operation, are used to skim the spit clean of primer as it travels on the return conveyor. Front and rear shell clamping fixtures, which are returned by a light chain conveyor on the opposite side of the plant to the spit conveyor, also become coated with primer and periodically are cleaned in a caustic bath.

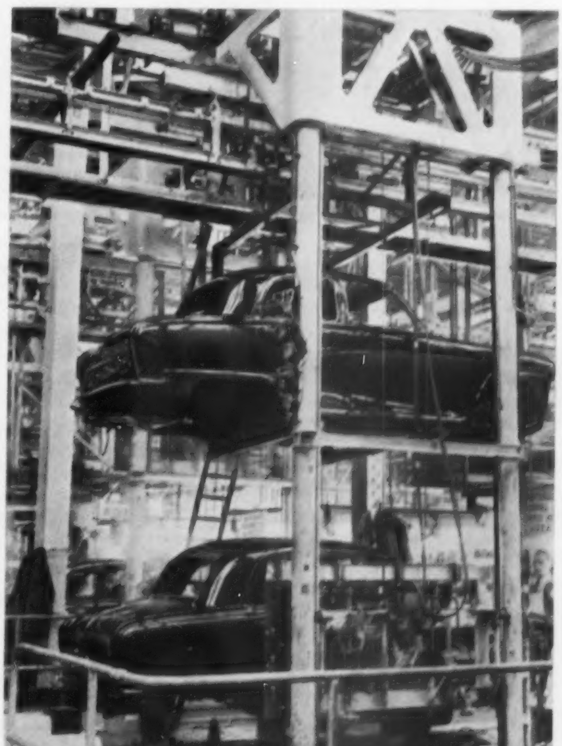
From the unloading platform the shell is hoisted on to an individual bogie and is then transferred, by one of three overhead cranes, to a buffer store comprising six lines of feeder tracks. An electric hoist transfers shells as required for sequencing from the feeder line to two laterally disposed lines for a number of secondary operations to be carried out. Minor fittings are attached; masking pressings are fitted in the trafficator apertures in the door pillars, a plate is secured to the front bulkhead to close an orifice provided to admit the spit, and a strut is attached to the radiator bulkhead. An examination is made, followed by metal rectification if required by file, grinder, abrasive sheet or panel tools.

The shell is then stopped-up, since file marks, grinding marks and adventitious abrasions are magnified by successive coatings and would impair the appearance of the final coat which, differing from a cellulose finish, is not polished smooth. Stopping is regularly applied to vulnerable locations such as door and panel margins. For the purpose of sound damping, a bituminous emulsion is sprayed on the top surface of the floor and certain other areas. Location or attachment points are masked during this operation.

When the Longbridge plant was reorganized for continuous flow production and fully mechanized assembly lines, it was necessary for the body-painting and body-trimming shops to be located between the engine factory and the car assembly building. The site is on the opposite side of a public highway and some distance from the earlier body factory which includes the press shop, welding shop and the Rotodip installations. It was not considered practical to remove and re-site this equipment, particularly the huge Rotodip plants. Accordingly, the primed shells are transferred from the body shop to the paint shop on articulated transporter vehicles.

On reaching the paint shop receiving bank the shells are lifted off by an electric hoist and placed on fork-lift trucks by which they are carried to and deposited on the suspension cradles of an overhead conveyor. They are elevated to the roof where they are switched to two parallel lines—A.30 saloon and A.40 commercial models on one and A.40, A.50

A finished body shell is lowered by this "body drop" on to the moving track in the body trim shop



and A.90 saloon models on the other—on which they are stored and released as required for sequencing. On this conveyor they are carried the length of the shop, are turned 90 deg and lowered to floor level, and are then brought on to a transverse line that is parallel to the paint shop and the body-trim shop lines.

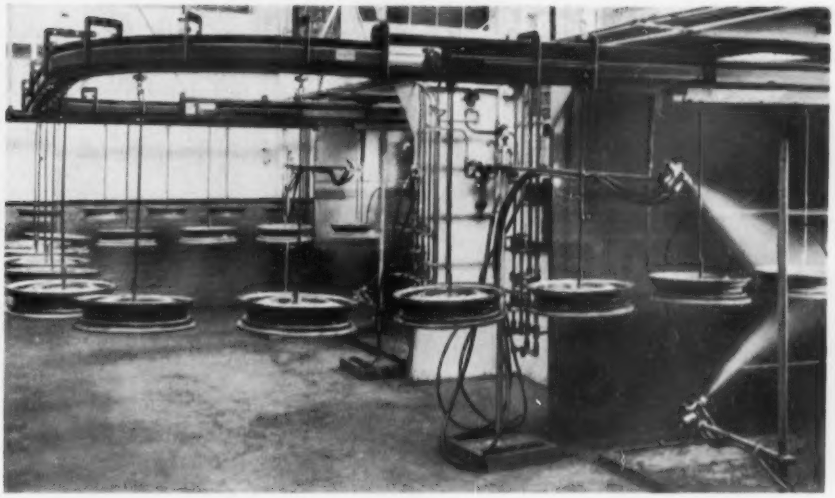
A primed shell is transferred from the feeder conveyor to the paint-shop conveyor by means of a so-called "tram" running on tracks between the two parallel conveyors. On the tram is a traversing carriage fitted with a parallel-link type lifting device. At a centralized control on a stationary platform an operator synchronizes the speed of the tram with that of the feeder conveyor, traverses the carriage to insert a pair of support rails under the shell, lifts the shell clear, traverses the carriage to the opposite side, lowers the shell on to the paint-shop conveyor and withdraws the support rails. The station on the paint-shop conveyor had been made vacant earlier by the transfer of a finished shell to the trim-shop conveyor by means of a similar tram.

On the paint-shop conveyor the shell is located on its suspension member by four dowels and manually secured clamps on a rotatable, counterbalanced cradle that can be spring-latched at any 45 deg increment of a full circle. The suspension member carries an overhead screen to shield the shell from drip or debris. About 6½ hours are required for a shell to pass from entry to exit of the paint shop and the meticulous care taken at every stage to inspect, rectify and check in order to ensure consistent quality, appearance and serviceability of the finish is most impressive. Despite the high degree of mechanization, the amount of hand work to achieve this end is considerable. In many sections, notably the successive rubbing down operations, gangs of men working on both sides of the shell are responsible for specific areas of the exterior.

Briefly detailing the operations in sequence, they commence with:

1. Rubbing down. First a localized operation to eliminate any runs of the primer at the lower margins of side panels, doors and similar points. This is followed by a rub-down with wet abrasive paper of the whole of the exterior.
2. Wipe down with wrung-out rags to remove the bulk of surface moisture.
3. Dry off in gas-fired tunnel at 280 deg F and cool-off in cold air tunnel.
4. Sound-damping emulsion is applied by brush to the door interiors and the undersides of the wings.
5. All joints and seams are dust-sealed by a bituminous material extruded from an air-operated gun.
6. Rub down exterior and face off stoppings.
7. The shell is given a spirit wipe-down, followed by a tack-off wipe.
8. The track then loops 180 deg and enters a spray booth. In common with other booths, this is equipped with a falling-water curtain and trough to carry off overspray and is air-conditioned under slight pressure. Atmospheric conditions are commendably good and most operators do not wear masks, although they are available for all. Operators, working on one side of course, apply the hot spray filler coating. The shell is partially rotated, for access to different areas, between each spraying station.
9. In a gas-fired tunnel oven that loops 180 deg the filler coating is stoved for 45 min at 310–320 deg F.
10. Cool off in cold-air tunnel.
11. Emerging from the tunnel the shell is carefully inspected and subsequently any necessary rectification of metal-work is carried out.
12. Where necessary, stopping-up with a rapid, air-drying synthetic material is effected.

In the car assembly building "body drops" lower finished and trimmed bodies in correct sequence on to the appropriate moving assembly tracks



Wheels are finished and dried at the rate of 264 per hour in this automatic electrostatic spray-painting plant

13. A wet rub-down then follows and stoppings are faced off. The track loops 180 deg.
14. After a wipe down with wrung-out rags, the shell is dried off in a gas-fired tunnel and a cold-air tunnel. The track loops 180 deg.
15. An inspection is made of the filler coating and rectification is carried out. The tracks loops 180 deg.
16. A spirit wipe and a tack-off wipe prepare the shell for the next coating.
17. In the second booth the sealer coating is sprayed on.
18. The shell is stoved in a tunnel for 45 min at 260 deg F and cooled off in a cold-air tunnel. Track loops 180 deg.
19. The sealer coating is given a dry scuffing.
20. Various inconveniently located areas, such as the filler compartment, the jack compartment, and several orifices, are sprayed with enamel.
21. An air blow-off is given to clear away loose abrasive, followed by a tack-off wipe. Track loops 180 deg.
22. In the third booth the final enamel coating is applied. Each operator has a battery of spray guns all primed and ready to deliver the colours currently in use. On a change of colour the operator merely hangs up the gun he has been using and selects the gun of appropriate colour from the rack.
23. The final coating is stoved for 60 min at 240 deg F and then cooled off in a cold-air tunnel.
24. After leaving the cool-off tunnel the track turns 90 deg to a transverse section. On this the final coating is inspected and any necessary rectification and touching-up is carried out.
25. The track then loops back 180 deg to a transverse line parallel to the trim-shop line. Here it is given the final inspection and is then transferred to the trim-shop line by the tram mentioned earlier.

On leaving the car assembly lines the bodies are given a final clean and a touch-up if necessary

In the trim shop the shells are elevated to the roof, switched above the appropriate trim lines, stored, and released by a " body drop " which, moving at a synchronized speed, lowers it on to the carrier fixture on the moving assembly track below. When trimmed, the bodies are conveyed to the central mechanized marshalling area where they are stored on feeder lines from which they are released automatically and in correct sequence on one of three overhead conveyor lines. The lines carry the bodies through a large tunnel to the car assembly building. Here they are again stored and released singly and in correct sequence to the appropriate assembly tracks where they are lifted up through the floor and then lowered on to the moving track by similar body drops. All marshalling and sequencing operations are controlled on a Hollerith punched-card system from a central control room.

Wheels are painted, in the wheel and tyre plant, with electrostatic spraying equipment. The plant has a capacity of 264 wheels per hour; 132 wheels constitute a full load of the overhead conveyor and the cycle time is 30 minutes. This time includes 5 min drying in an infra-red oven and 5 min in a cooling tunnel. The wheels are suspended horizontally and are rotated as they are carried through the two spray booths. In each booth the spraying area is surrounded by a copper grid which has a static charge of approximately 100,000 volts.

Prior to the wheel entering the first booth a single gun sprays the rim interior. Then as it passes through each booth two guns, one above and one below, spray continuously at angles of 45 deg over the faces of the wheel. As a consequence of the difference of potential between the spray equipment and the work, the paint is attracted to and deposited on the wheel. It is estimated that the usual overspray is reduced by about 50 per cent by this method.

FIREBIRD II

The Second Experimental Gas Turbine Car by General Motors Corporation

TWO years ago General Motors built an experimental gas turbine-propelled car designated the Firebird.* This was purely a test vehicle; a single-seater with a fabric-reinforced plastics body, a centrally mounted power unit exhausting horizontally to the rear, and a nose-mounted 35-gal fuel tank. Its weight was approximately 2,800 lb and the turbine was stated to develop 370 b.h.p. Accordingly, it was estimated that the car should be capable of speeds in excess of 200 m.p.h. Firebird II is a much advanced development of the earlier vehicle and is a four-passenger car equipped for operation on the public highway as well as on the tracks of proving grounds.

The new turbine unit GT-304, like its predecessors GT-300 in the Turbocruiser and GT-302 in the Firebird, is of the two-shaft type with the single-stage centrifugal air compressor driven by the h.p. turbine and useful power being delivered by an independent l.p. turbine. It is obviously a much less bulky unit as it develops "more than 200 h.p." at compressor- and power-turbine speeds of 35,000 r.p.m. and 28,000 r.p.m. while the GT-302 unit was operated at speeds of 26,000 r.p.m. and 13,000 r.p.m. respectively. The maximum gas temperature has been raised to 898 deg C from the previous 815 deg C. Weight of the unit complete with accessory equipment is slightly higher at approximately 850 lb against the 775 lb of GT-302.

Regenerative heat exchanger

The most important innovation, however, is the inclusion of a regenerative type heat exchanger. Although complete details are not available it would appear to be of the drum type, rotated at a ratio of 1 : 1000 of the compressor speed, say 20 to 30 r.p.m. Mounted in the drum are a number of matrices which are passed successively through ducts carrying the combustion products from the power turbine to the exhaust stacks and then through ducts conveying air at maximum pressure from the compressor to the combustion chambers. The matrices, which may possibly be of wire gauze or honeycomb coils of fine wire, absorb heat from the exhaust gas stream and then give it up to the air stream from the compressor.

This type of heat exchanger is more effective and less bulky than the recuperative type in which the heat has to be transferred through the walls of tubes or plates and it is claimed to be, to some extent, self-cleaning as clean air passes through the matrices alternately with the combustion products. A difficulty encountered with this type is the prevention of leakage, since the air from the compressor is at the highest pressure of the cycle and the exhaust from the turbine is at the lowest cycle pressure. No details are given of the sealing arrangements employed but the claim is made that 80 per cent of the heat of the exhaust gas, that would otherwise be lost to atmosphere, is recovered.

It is reported that the exhaust temperature is lowered as much as 538 deg C and instead of being a searing blast is merely comfortably warm. Naturally, with a saving of heat of such magnitude the amount of fuel to be burned to maintain the operating temperature at the turbine entry is much reduced. As a result, the specific rate of fuel consumption is stated to "approach that of a piston engine".

A specially designed automatic starting system is provided. Depression of the starter button starts up the Delco-Remy motor and energizes the ignition plugs in the combustion chambers. When the compressor turbine has been brought to a speed of 4,000 r.p.m. fuel is delivered at the burners and, following ignition of the fuel, the motor continues to assist the turbine until its idling speed of 15,000 r.p.m. is reached. At that speed the motor and the ignition plugs are automatically cut and thereafter the vehicle can be driven off.

In Firebird II the turbine unit is mounted in the conventional forward position and the two exhaust ducts run to the rear inside the framing sills of the integral body. Immediately to the rear of the saloon the ducts are turned upwards to discharge vertically from ports located on each side of the body behind the rear window. An intake air silencer is provided and since there are no pulsations in the exhaust the car is as quiet as a good piston-engined vehicle.

* "Automobile Engineer", October, 1954

The experimental Firebird II has a two-shaft turbine power unit which develops more than 200 h.p. and is equipped with a regenerative heat exchanger. The integral body has a skin of titanium

Body features

Overall dimensions of the vehicle are length 19 ft 6¾in, width 5 ft 10½in and height 4 ft 4¾in. The wheelbase is 12 ft and the wheel track is 5 ft at the front and 4 ft 9in at the rear. The integral body, of so-called aerodynamic form with a low, tapered nose and with a dorsal fin on the rear deck, is remarkable in that the skin is of titanium. Each of the two nose apertures provides an intake for turbine air and also a smaller inlet for air to the oil cooler. At a higher level and slightly to the rear are the retractable headlights. The bonnet lid is hinged below the windscreen, and in the centre of the lid are two angled air outlets from the turbine compartment. Their lids, when opened, serve as deflector flaps and reduce wind noise. Below the windscreen and behind the front wings are air inlets to the saloon, the flaps opening automatically when the air-conditioning unit is functioning.

Two fuel tanks are mounted externally; they are suspended horizontally behind the rear wheels from extensions of the wings. Rear air inlets are arranged in the nose of each fuel tank and, assisted by two blowers located inside the body, deliver air to cool the condenser of the air-conditioning unit. The dorsal fin is not merely a decorative appendage; it is designed to move the centre of pressure towards the rear and thus improve directional stability.

Entrance to the body is obtained by inserting a key in the slot of either of the two doors. This action operates a switch that raises a glass roof panel and gives access to an interior push button, depression of which releases the door. When seated inside, depression of a push button on either door closes the roof panel. The illustrations show no exterior door handles.

Suspension

All wheels are independently suspended, the front wheels on double wishbone arms and the rear wheels on longitudinal and transverse arms swinging alongside the frame sills and behind the rear transmission unit respectively. Suspension pivots are fitted with lubricant-impregnated Teflon reinforced plastics bearings to provide permanent lubrication and give a measure of acoustic insulation between the suspension members and the body structure. Additionally the bearings for the rear suspension are mounted on rubber cushions. Conventional springs and shock absorbers are replaced by Delco-matic oleo-pneumatic suspension equipment, developed by the Delco Products Division of General Motors.

Relatively small wheels are fitted and the tyre diameter is only 27·3in. The Delco-matic air-oil unit installed at each wheel is cylindrical in shape, being about 4½in diameter and 8½in long. Its steel outer casing is connected to the body framing and arranged co-axially within it is a small hydraulic cylinder and piston, the rod of which is connected to the wheel suspension member. A cylindrical rubber separator divides the annular space between the hydraulic cylinder and the casing. Oil fills the cylinder above the piston and also the communicating space between cylinder and separator, which is in communication with the cylinder. Air under pressure is confined in the space between separator and outer casing.

A levelling system is incorporated to adjust the clearance between wheels and frame irrespective of the number of passengers or load carried. The suspension cannot "bottom" when loaded and an even keel is maintained which avoids tilting the beams of the headlights. To level the car the height of the piston in the hydraulic cylinder of each suspension unit is adjusted by a control valve admitting or returning oil to the central hydraulic system. While the car is in motion the levelling circuit is shut off at the height control valves by hydraulic pressure. In operation, when the wheel lifts on the bump, the piston is raised in the cylinder and oil is displaced to the space within the rubber separator. The separator is expanded against the external cushion of air which reacts in the manner of a variable-rate spring and bottoming is not possible.

Transmission

From the reduction gear unit at the rear of the power turbine the drive to the transmission unit, rubber-mounted on the frame between the rear wheels, is by a propeller shaft enclosed in a tunnel which forms the central structural member of the body framing. By dividing the shaft and

When the vehicle is in operation, a multiplicity of flaps somewhat mars the sleek aerodynamic appearance of the body

coupling the two sections with a universal joint, the projecting height of the tunnel in the floor of the saloon is reduced to a minimum. The automatic transmission unit comprises a fluid coupling and a four-speed planetary gear set with a take-off shaft that allows rear-mounted auxiliary and accessory equipment to be driven while the car is stationary. Axle shafts with a universal joint at each end transmit the drive to the rear wheels, the inner joint being of the sliding type.

Control is effected by an electrical gear-shift designed by Delco-Remy. It embodies a two-step solenoid and when the driver sets the control lever to "Drive", one part of the solenoid coil is energized and the armature moves in only part way. When "Reverse" is selected the armature moves in to full stroke. A mechanical linkage coupled to the armature performs the shifts but since operation is electrical, the control can be located remotely from the selector without difficulty. When the car is parked the propeller shaft is locked by a pawl engaging a gear; during normal operation the pawl is retracted by a solenoid.

Braking system

An aerodynamically shaped vehicle with turbine propulsion demands brakes of high efficiency and consistent reliability. Those fitted to Firebird II are of the disc type engaged by metal friction pads. Presumably the friction material will be a sintered metal. It is claimed to be unaffected by dirt or moisture. Developed experimentally by Moraine Products Division of General Motors, the brake is termed the Turbo-X in reference to the internal cooling system embodied in the disc. The cast iron disc has an air space between its two braking surfaces which is bridged by vanes. When the disc is rotating these vanes draw in air at the inner periphery, pass it between the braking surfaces and discharge it from the outer periphery, thus accelerating the dissipation of heat generated while braking.

The brakes are hydraulically operated from a master cylinder, the foot pressure being multiplied at a constant ratio by a power booster energized from the vehicle's central hydraulic system. Under normal operating conditions the metal pads will have a working life several times as long as that of conventional friction materials and precise adjustment is possible as closer tolerances can be arranged for the metal components.

Centralized hydraulic system

A high-pressure pump driven from the transmission unit charges two hydraulic accumulators with oil at a pressure of 1,000 lb/in². From these, hydraulic energy is supplied as required for power-assisted steering gear, power-assisted brakes, air-oil wheel suspension units and the windscreen wiper. When the accumulator pressure reaches 1,000 lb/in² the pump is automatically unloaded but immediately the pressure has fallen to 850 lb/in², it cuts in and recharges the accumulators to the designed maximum pressure of 1,000 lb/in². Hydraulic energy is available for all services, whether the vehicle is in motion or stationary. It is also supplied when the turbine is shut down, providing the ignition circuit is still closed. When the ignition is switched off, check valves are closed electrically to ensure that pressure in the accumulators is maintained.

Electrical system

The basis of the electrical system is a 100-amp Delco-Remy alternating current generator. This AC generator has better voltage-speed characteristics than a DC unit and can deliver almost its rated output when the turbine is running at idling speed. Its overall dimensions are also relatively much reduced. A new type transistor voltage regulator controls the generator output. The charging system uses a rectifier to produce direct current for the 12-volt storage battery.

At the tail of the car the rear lights, stop lights, reversing lights and direction signal lights are all grouped in a single unit and are reflected by a large parabolic mirror. Common bulbs are used for reversing and stop lights. The red filters for stop light use are lowered automatically by means of a solenoid when the transmission control lever is placed at "Reverse". When reversing, the lower half of the rear lights continue to show red.

Accessory equipment

Installed in the car are many items of accessory equipment, some of a purely experimental character. There is two-way radio, a television screen with synchronization controls, an air-conditioning unit, a water-cooler and a cooling chamber for food. A small closed-circuit television set has a camera at the rear of the car and on the instrument panel a viewing screen which replaces the conventional rear-view mirror.

The television and synchronization equipment actually fitted would enable the vehicle to be locked on the beam of a futuristic, electronic "Safety Autoway". Electronic pick-up coils, located in the air intakes at the front end of the car, would receive the beam from the transmitting tower of the highway and the vehicle would be automatically directed in the manner of an aircraft flying "on the beam". Under such conditions the steering wheel would be retracted close to the instrument panel, to be pulled out again when required for manual operation.

Recent Publications

Brief Reviews of Current Technical Books

Basic Lubrication Practice

By Alan F. Brewer.

New York and London: REINHOLD PUBLISHING CORPORATION, 430 Park Avenue, N.Y. 22; and CHAPMAN AND HALL LTD., 37 Essex Street, W.C.2. 1955. 9½ × 6. Price 54s.

Designing for lubrication contributes much to dependable operation at minimum cost. Moreover, the cost of lubrication is generally insignificant by comparison with the cost of the machine and its value as an operational unit. The book is intended to bring home to the operator the importance of lubrication in protecting his machinery, and to enable him to make a wise selection of lubricants and lubricating equipment. It is also intended to serve as a text book for college or trade school students and to supplement the valuable information that the petroleum industry makes available.

Know Your Tractor

London: THE SHELL PETROLEUM CO. LTD., Shell-Mex House, W.C.2. 1955. 10 × 7½. 356 pp.

This book is being given free of charge to technical colleges and other educational establishments with agricultural departments, as well as to organizations concerned with agricultural tractors. Copies are also available to users of this type of machinery but, of course, the supply is limited. The text includes a discussion of fuel, combustion and lubrication, as well as to other aspects of tractor operation and maintenance. This work has been written largely from the point of view of the user and so relates principles of operation to the requirements of maintenance. Tractors of the types used on farms and in general service are dealt with, but the smaller machines used in horticulture are excluded. The information given is intended to supplement that in operators' manuals issued by tractor manufacturers.

The chapters dealing with the various components of the tractor are approximately in the same order as that in which the components are arranged in the power train. In other words, the book begins with combustion of fuel, and ends with power take-off or belt drives. Thus, chapter 1 provides a general introduction to the internal combustion engine and includes a brief comparative note on fuels. The next two chapters are devoted entirely to fuels and fuel systems. In the succeeding chapters, the governor, air filtration, electrical equipment and the engine cooling system are discussed. Chapter 8 is devoted to the principles of lubrication and is not confined to the tractor engine. The next chapter is on engine lubrication systems, while chapter 10 deals with the performance and maintenance of the oil in lubrication systems. Chapters 11 to 13 cover the transmission, ground drive and power applications. Under the last heading, there is a discussion of drawbar hitches and stability. Next, two chapters are devoted to attention required by the tractor when not in use, and notes on the storage of fuels and lubricants are included.

Plastics Tooling

By Malcolm W. Riley.

New York and London: REINHOLD PUBLISHING CORPORATION, 430 Park Avenue, N.Y. 22; and CHAPMAN AND HALL LTD., 37 Essex Street, W.C.2. 1955. 7½ × 5. 123 pp. Price 20s.

This work is one of the Reinhold Pilot Book Series. The aim in the publication of the Pilot Books is at providing comprehensive sources of information on new materials, processes or technologies. It is intended that new developments in all fields of science and technology will be covered as they occur. Although plastics tooling is still in its infancy sufficient experience has been gained to show that plastics can provide outstanding advantages when used properly for certain types of tools. This book is intended to present simply the up-to-date knowledge on resins, methods employed, and the major applications. The discussion in this book is not highly technical, in that it does not probe deeply into the chemistry of the materials, but the effects of the composition of the plastics are covered. Only materials which are formed in the uncured state and then cured are dealt with in the work.

SIX-WHEELER BOGIE DESIGN

Notes on Load Transfer and Floatation

R. Dean-Averns

In six-wheeler bogie design, it must be realised that to some extent the magnitude of the transmitted loads is bound up with the structural dimensions, and, in turn, these dimensions have considerable bearing upon performance, Consider, therefore, the influence of bogie spacing as a percentage of the wheelbase and its influence upon steering and also the loading of the frame through bogie drag. Furthermore, upon this ratio depends the frequency of shock loading transmitted to the frame when the vehicle passes over an obstacle.

With reference to steering, it is desirable to retain as small centres as possible for bogie wheel spacing, although the actual minimum dimension is governed by tyre size and the necessary clearance between tyres. From previous data with particular reference to goods vehicles a ratio of between 4·1/8 to 4·1/2 to 1 has been found to give very little imperfection in the steering diagram. The assumption that the bogie necessarily resists steering is not wholly substantiated, since it depends partly upon the layout and design of radius rods if such be included.

Should they be oblique or the road springs positively cambered, then there is a definite steering action within the bogie itself. Such an action is illustrated by Fig. 1. If the rods are horizontal and are laid down so that they align the axles, there may be some resistance to steering. In the first instance, when the vehicle is rounding a bend, and its centre of gravity is displaced transversely, centrifugal force imposes a greater load on the outer spring, which if positively cambered spreads its centres, whilst the inner spring, being less heavily loaded shortens its centres, and the axles align themselves accordingly.

As compared with the four-wheeler, and due to the pivotal mounting of the road springs, both the upward acceleration and the displacement of the frame are halved when any obstacle is encountered. Assuming an acceleration of 1ft/sec/sec which is considered to be the maximum for riding

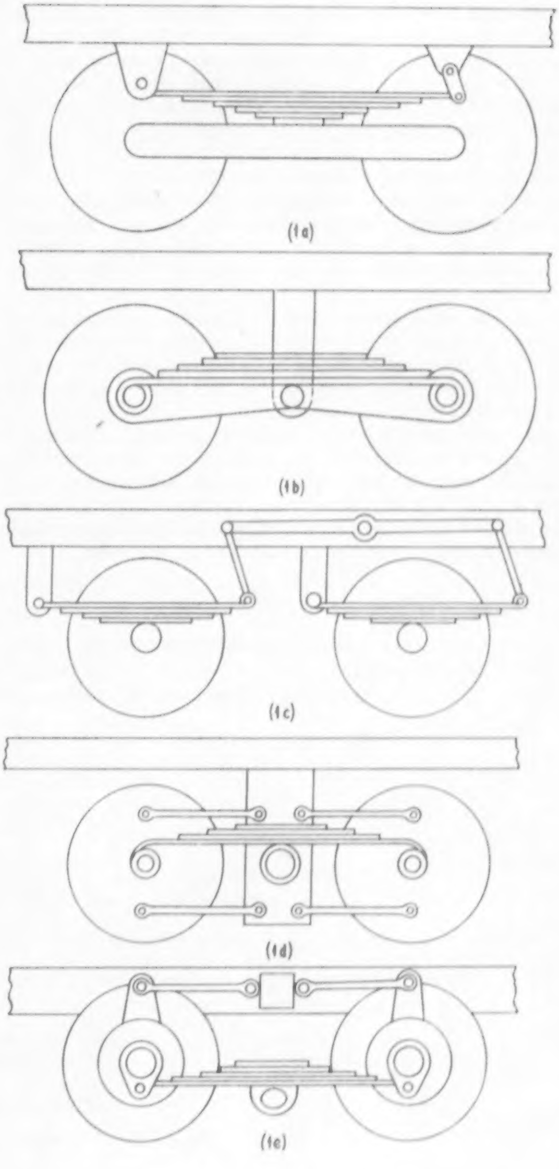
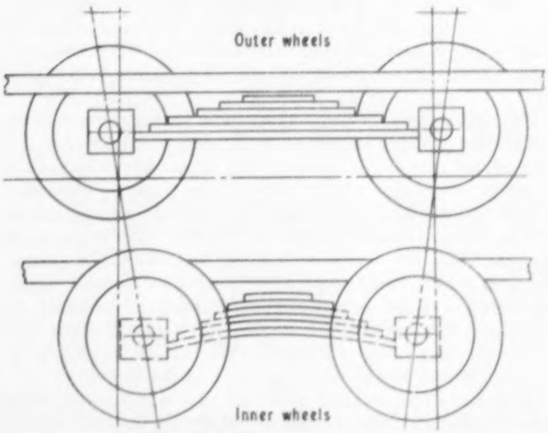


Fig. 2. Typical bogie suspensions.

Fig. 1. Condition for definite steering action within the bogie. On the outer wheel suspension there is increased spring deflection due to load transfer ; on the inner wheel suspension there is increased camber due to load reduction.



comfort and using this as a basis for comparison, an approximation may be made as follows.

Maximum acceleration of the body

$$= \frac{g \times \text{road depression in in.}}{\text{static deflection of the spring in in.}}$$

For a spring deflection of 4in and a depression of 1½in the body acceleration is 12·07 feet per sec² on a four-wheeler whilst the effect of the depression upon the frame structure of the six-wheeler is 6·03 ft per sec² with the number of shocks doubled. The frequency of these shocks is perhaps of more importance than the magnitude, as the ideal is more nearly approached when the number is greater and the magnitude reduced. Whilst the amount of rise and fall of the sprung structure weight is halved, the time taken remains unaltered and again the velocity of fall is reduced so that since the force of impact is $\frac{MV}{2}$ where M = sprung

mass, and V = velocity of fall, it follows that the actual impact force at the frame or at the point of bogie attachment is but one quarter of that encountered at the road wheel.

All these features have a direct bearing upon the requirements of the vehicle structure. Consider for a moment the type of bogie having compensated spring linkage, with spring attachment brackets taking the frame weight, and arranged remote from the bogie centre. It is quite possible that such a linkage can produce unequal load distribution at the road wheels, although it will distribute the dynamic deflection due to road shock on either side of the vehicle. Correct compensation between the two springs on one side of the chassis is dependent upon frame rigidity, and accurate compensation is impossible if the frame experiences undue deflection at any point between the extreme spring brackets, but with the centrally pivoted bogie wherein there is complete freedom for pivotal motion, this difficulty is eliminated. There is, of course, a greater localization of stress at the frame attachment point, but this is taken care of in the initial frame design. Articulation of the complete frame structure is possibly desirable and the tendency should therefore be to reduce the number of points of support, since a vehicle suspended by a compensated link system would be much more severely stressed when subjected to distortion.

Fig. 2 shows at 1a a type of construction in which a plain bar is arranged between the two axles, the single spring being centrally fixed and shackled to the frame at each of its ends. In this case the bar takes axle torque but it is not subjected to twist due to wheel movement. The torque reactions not only impart a strong torque moment to the frame, but they transfer considerable weight from one axle to the other. This design therefore lies in the first category.

A similar thing occurs in a reverse direction in the design of the "rocking bar" type as it is known, wherein two separate springs on each axle are attached to a short centre bar. In the design shown at 1b in Fig. 2, a single spring is pivoted on the axle centre line and each axle is located by centrally mounted torque arms. This arrangement belongs to category (b).

Another arrangement of rocking bar suspension is shown at 1c in Fig. 2. The independent springs, and long pivoted bar connection to the rear ends of each spring eliminate axle to axle weight transference, but definitely permit torque transference to the frame and thus it is classed in category (c), The last two examples are widely adopted arrangements, and closely approximate each other in principle. In one a single spring is mounted on a central bogie pivot, having torque arms above and below the axle centre, in which the

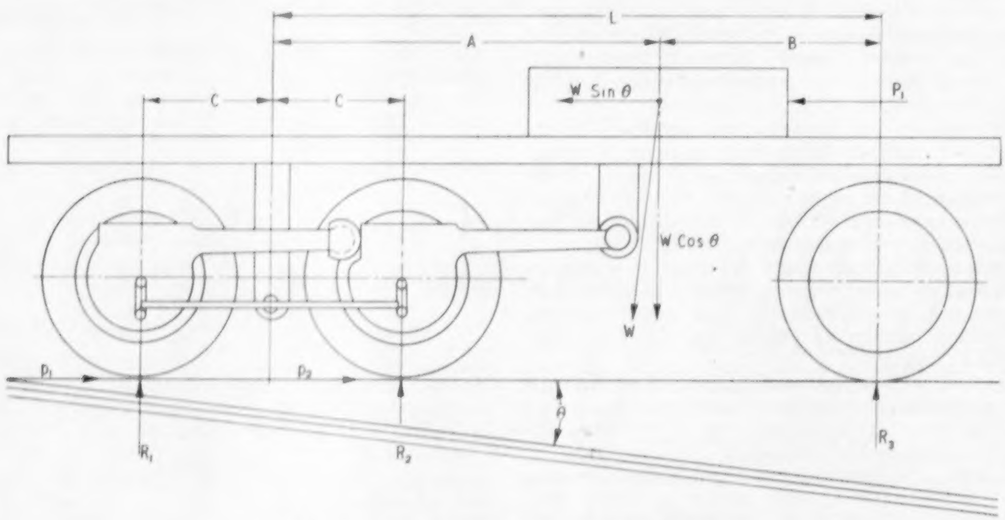


Fig. 3. Reaction diagram for one type of twin drive layout.

Most rigid frame six-wheelers are designed so that *when stationary*, the wheel loading is equal on all bogie wheels, but as previously commented, according to the layout of torque reaction arms, this state is immediately destroyed when driving torque is applied to the wheels. The magnitude of this reaction force transmitted to the frame, varies with the method employed for its absorption. The tendency is to transfer weight from the forward driving axle to the rear driving axle in varying degrees and it is therefore desirable to recount the different methods of torque absorption in various bogie designs. General design falls into one of four categories, shown in Fig. 2.

1a Suspensions which do permit weight transference between axles and which also exert a torque on the frame.

1b Those which transfer weight between axles but exert *no* torque on the frame.

1c Those which have no tendency to transfer weight, but which *do* transmit torque reaction load to the frame, and

1d Those which have neither tendency.

primary torque reaction of the axles is resolved in a horizontal direction along the torque arms, and thus permits no transference of weight between the axles. There is however some slight degree of torque transmitted to the frame, but for general purposes the design may be included in category (d).

The second design in this category is shown in the bottom illustration. It is a simplified arrangement of the first type. The spring acts as the lower torque arm, and the upper set of arms are pivoted at the centre on the frame. The main functional difference between the two last arrangements, lies in the fact that in the last the centre bogie trunnion is located *below* the wheel centres, so that the slight torque moment on the frame owing to torque rod loads due to slight inaccuracies of the arrangement of the links is balanced by the opposing moment of inertia force acting about the trunnion centre line. There is therefore, substantially no weight transfer and no torque reaction on the frame.

It is not suggested that these are the only designs of six wheeled vehicle, indeed there are many others, but they are

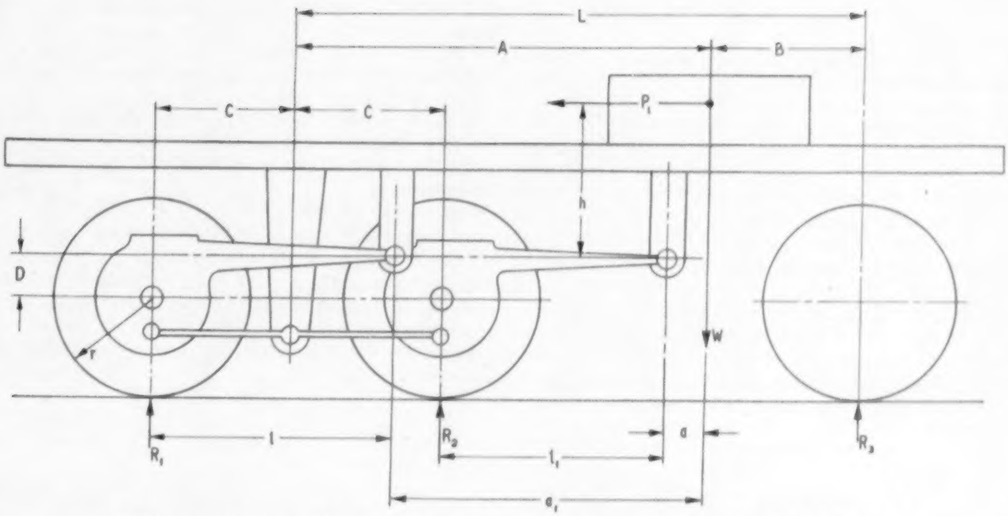


Fig. 4. Reaction diagram for a twin drive layout with the two torque arms anchored to the frame.

typical, and serve to illustrate the effect of torque and weight transference to the frame or structure.

Analysing these phenomena a little further, upon the assumption that all the torque is utilised in producing vehicle motion, and that all wheels are revolving at uniform speed, we take as a first example a very well known type of twin drive layout in which two torque tubes are provided as in Fig. 3. In this layout the forward thrust tube of the middle axle is anchored movably to the frame and the forward end of the rear tube socketed into the rear of the middle axle case. The springs in this case are pivoted at their centres to fixed frame brackets and shackled at their ends to the axle casings.

From the two following equations it will be seen that the alteration in the reactions due to torque exerted in producing acceleration is represented by the second terms in the expressions, whilst those adjustments due to the torque producing tractive effort, may also be ascertained from previous values of R_1 and R_2. Since the first term $\frac{WB}{2L}$ represents the static value of R_1 and R_2 reactions, the results from previous conditions for acceleration, tractive effort, and rolling resistance, etc., will be added to or deducted from it, to produce the final reactions.

Should the two torque arms each be anchored to the frame as in Fig. 4 instead of the forward arm only, the reactions are somewhat different and R_1 would equal

$$\frac{WB}{2L} + \frac{(T+T_1)h}{2rL} + \frac{r+D}{2rlL}[T(2L - a_1 - B) - T_1(a + B)]$$

whilst R_2 becomes

$$\frac{WB}{2L} + \frac{(T+T_1)h}{2rL} - \frac{r+D}{2rlL}[T(a_1 + B) - T_1(2L - a - B)]$$

and if $T = T_1$

then $R_1 = R_2$ or $\frac{WB}{2L} + \frac{(T+T_1)h}{2rL}$

As in the previous example, should all the torque be utilised to produce acceleration then

$$R_1 = \frac{WB}{2L} + \frac{T}{2Ll}(2L - a_1 - B) - \frac{T_1}{2Ll}(a + B)$$

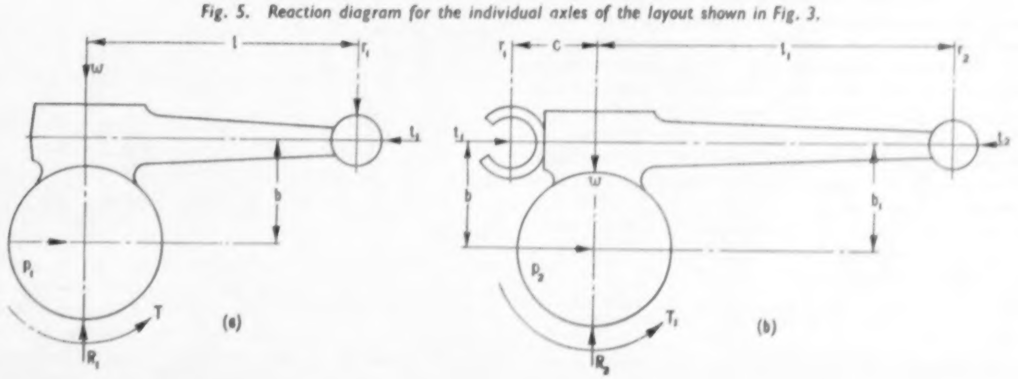
and $R_2 = \frac{WB}{2L} - \frac{T}{2Ll}(a_1 + B) + \frac{T_1}{2Ll}(2L - a - B)$

and again if $T = T_1$

then $R_1 = R_2$ or $\frac{WB}{2L} + \frac{(T+T_1)}{2L}$

It is seen that the fundamental equations for equilibrium

Fig. 5. Reaction diagram for the individual axles of the layout shown in Fig. 3.



of the driving wheels on any type of vehicle are, with notation wherein

p_1 and p_2 are the tractive efforts at the wheels.

W = total vehicle weight.

w = weight at each axle.

P_1 = total resistance.

p_R = resultant force acting at the centre of gravity of vehicle.

$R_1\ R_2\ R_3$ = ground reactions.

$r, r_1\ r_2$ = running radius of tyres.

T, T_1 = torque applied to axles.

$t_1\ t_2$ = horizontal component of T_1 along axle torque tube.

$p_R = p_1 + p_2 = W \sin\theta$

and $W_R = R_1 + R_2 + R_3 = W \cos\theta$

also that $p_1 r = T$ and $p_2 r = T_1$

Treating each axle separately in order to find the conditions of equilibrium of each axle, reference to Fig. 5 shows that for the rear axle

$p_1 = t_1, R_1 = w + r_1, r_1 l = T + t_1 b$

and for the front axle.

$t_2 = p_2 + t_1$ which equals $p_2 + p_1$

and $R_2 + r_1 = w + r_2$

whilst $r_1 c + r_2 l_1 = T_1 + t_2 b_1 - t_1 b$.

The next step is to ascertain the equilibrium of the frame and from Fig. 6 it will be seen that

$W = 2w + r_2 + R_3$

and by moments $2wA + r_2 a = t_2 h + R_3 b$

so that we can now say $r_1 = \dfrac{T(r + b)}{rl}$ where r = running radius of wheels

and $r_2 = \dfrac{T_1(r + b_1)}{rl_1} - \dfrac{T[rc + b(c + l) - b_1 l]}{rll_1}$

$2WA = (p_1 + p_2)h + (W - 2w - r_2)B - r_2 a$

$\therefore 2WL = WB + \left(\dfrac{(T + T)h}{r}\right) - r_2(a + B)$

Therefore if the torque at the front driving axle is $\dfrac{T + T_1}{2}$ and slip is about to take place then the maximum value of T_1 will equal $T_1 = \mu r R_2$ in which case $R_2 = \dfrac{T \quad T_1}{2\mu r}$

and if this value of R_2 be substituted in the previous expression for reactions for equal torques in each axle then the value of slipping torque can be found, and will be represented as

Torque (slipping) =

$$\frac{WBr}{\dfrac{L}{\mu} + \left(\dfrac{1K(r + 2b_1 - b) + (r + b)(2Ll_1 - Kc)}{2ll_1}\right) - h}$$

Two other conditions arise, if a third differential is *not* included in the design in which the distribution is modified as between the two axles and in consequence two other conditions of frame loading occur. They both concern wheel slip. In the first case, the wheels of the front driving axle are on the point of lifting from the ground and the second occurs when all wheels on the driving axles are on the point of slipping. In the first case R_2 will be zero, and the assumption in the second case is that T and T_1 are proportional to R_1 and R_2.

In the first case then $R_2 = 0, p_2 = 0, T_1 = 0$ and T = total torque and substitution of these values in the expressions for spring reactions gives

$$w = \frac{WB}{2L} + \frac{(T+T_1)h}{2rL} + \frac{T+T_1(a+B)[1(b-b_1)+c(r+b]}{2rll_1L}$$

and if, in the equation for equilibrium of front driving axle, the values of r_1 and r_2 be substituted since $R_2 = 0$ and $w = r_1 - r_2$

$$w = \frac{T + T_1}{rll_1}[(r + b(c + 1_1) + 1(b - b_1)]$$

If these values of L be equated and the expression solved for total torque the magnitude of the torque which will cause the front driving axle to lift off the ground will be represented as

lifting torque =

$$\frac{WBrll_1}{1(b-b_1)[2L-(a+B)]+(r+b)[2L(C+l_1)-c(a+B)]-hl.l_1}$$

and the corresponding value of R_1 is found by further substitution of these values of r_1 and w in the expression represented as

$R_1 = w + r_1$

and that we find

$$R_1 = \frac{T + T_1}{rll_1}[(r + b)(c + 2l_1) + 1(b - b_1)]$$

so that the spring force w equals

$$w = \frac{WB}{2L}\frac{(T + T_1)h}{2rL} - \frac{T_1(r + b_1)(A + B)}{2rl_1L} + \frac{T[rc + b(c + l) - b_1 l](e + B)}{2rll_1L}$$

and R_1 may be found by substituting for w and r_1 in the expression

$R_1 = w + r_1$

thus if $K = c(a + B) + 2l_1L$

$$R_1 = \frac{WB}{2L} + \frac{(T + T_1)h}{2rL} - \frac{T[K(r + b) + l(a + B)(b - b_1)}{2rll_1L}$$

and by similar substitution in the expression

$R_2 + r_1 = w + r_2$

if K in this case equals $(e + B - 2L)$ then

$$R_2 = \frac{WB}{2L} + \frac{(T + T_1)h}{2rL} - \frac{T_1K(r + b_1)}{2rl_1L} + \frac{T[(r + b)(Kc - 2Ll_1) + Kl(b - b_1)}{2rll_1L}$$

Before the values of R_1 and R_2 can be finally assessed it is necessary to know the torque distribution between the two driving axles, which as previously shown can vary according to the bogie construction. In cases wherein a third differential is fitted $T = T_1$ that is, the driving torque is evenly distributed so that R_1 becomes,

$$R_1 = \frac{WB}{2L} + \frac{(T+T_1)h}{2rL} - \frac{T+T_1[l(e+B)(r+2b_1-b)-K(r+b)]}{4rll_1L}$$

and

$$R_2 = \frac{WB}{2L} + \frac{(T + T_1)h}{2rL} - \frac{T + T_1[lK(r + 2b_1 - b) + (r + b)(2Ll_1 - Kc)]}{4rll_1L}$$

Furthermore, should the two torque arms be similarly dimensioned from the axle centre line, that is $b = b_1$, the expressions for reactions R_1 and R_2 can be further simplified and

$$R_1 = \frac{WB}{2L} + \frac{(T + T_1)h}{2rL} - \frac{T + T_1(r + b)[l(a + B) - K]}{4rll_1L}$$

whilst

$$R_2 = \frac{WB}{2L} + \frac{(T + T_1)h}{2rL} - \frac{T + T_1(r + b)[lK + 2Ll_1 - Kc]}{4rll_1L}$$

The maximum amount of torque which can be applied to the driving axles is however dependent upon the limit of the coefficient of adhesion between tyre and road, which if exceeded will promote wheel spin, but if on the other hand this coefficient is greater than the applied torque then

increased torque can be applied to the limit of the tendency of the forward driving axle to slip, that is of course providing the torque is evenly distributed between the axles.

In this condition the limiting value of the adhesion coefficient before wheel spin occurs may be found by inserting the value of $\mu r R_1$ in place of $T + T_1$ in the equation for lifting torque

$$\text{and } \mu = \frac{ll_1}{(r + b)c + 21_1) + 1(b - b_1)}$$

The other condition, wherein all driving wheels begin to slip nullifies the previous equation $p_1 r = T$ and $p_2 r = T_1$ and produces in their places

$p_1 = \mu R_1$ and thus $T = \mu r R_1$

$P_2 = \mu R_2$ and thus $T_1 = \mu r R_2$

so that if the equations for equilibrium include these values, R_1 and R_2 will be

$$R_1 = \frac{2WB(1 - l\alpha)}{(\delta - 2\beta\eta)(1 - l\alpha) - [1 - \beta(C + 2l_1][2\mu h - 2l\alpha(a + B)] + 2l\gamma(a + B + \mu h}$$

$$\text{where } \alpha = \frac{\mu(r + b_1)}{ll_1}$$

$$\beta = \frac{\mu(r + b)}{ll_1}$$

$$\gamma = \frac{\mu(b_1 - b)}{ll_1}$$

$$\delta = 4L - 2\mu h$$

$$\text{and } \eta = C(a + B) + 2Ll_1$$

whilst R_2 will equal $\dfrac{R_1[1 + \gamma l - \beta(c + 2l_1)]}{1 - l\alpha}$

and the torque $T = \mu r(R_1 + R_2)$

We are now at the stage when this analysis may be devoted to the condition which exists when all torque is utilised in accelerating the driving wheels, so that

$$r_1 = \frac{T}{l} \text{ and } r_2 = \frac{T_1 l - Tc}{ll_1}$$

and from the previous equations for frame equilibrium

$$2w(A + B) = WB - r_2(a + B)$$

$$\text{from which } w = \frac{WB}{2L} - \frac{(T_1 l - Tc)(a + B)}{2ll_1 L}$$

$$\text{and } R_1 = \left(\frac{WB}{2L} + \frac{T}{l}\right) - \left(\frac{(T_1 l - Tc)(a + B)}{2ll_1 L}\right)$$

$$\text{whilst } R_2 = \left(\frac{WB}{2l} - \frac{T}{l}\right) - \left(\frac{a + B - 2L(T_1 l - Tc}{2ll_1 L}\right)$$

Should a third differential be included or should each axle take equal torque so that $T = T_1$ then

$$R_1 = \frac{WB}{2L} - \frac{T + T_1}{4ll_1 L}[(a + B)(l - c) - 2l_1 L]$$

$$\text{and } R_2 = \frac{WB}{2L} - \frac{T + T_1}{4ll_1 L}[a + B - 2L(l - c) + 2l_1 L]$$

We may now proceed on similar lines to set down the reactions for the more popular present day designs as illustrated in Fig. 7. Type (a) includes pivoted mounting of the spring ends to each axle, rigidly fixed at the centres to a trunnion, which in turn is allowed to pivot on the end of a cross member. The centre of this trunnion in relation to the centre of the wheel axes is important as will be seen by the following expressions. There are no torque arms as in the previous examples, and thus the springs function not only as medias of suspension but also as a means of torque absorption. In the example R_2 decreases as the torque increases and if the torque be equal in both axles the limit which can be absorbed is measured by the tendency of the front driving wheels to slip. Should the torque not be equally distributed then the limit to the torque is the tendency of the front driving wheels to lift or the tendency of all driving wheels to slip.

Deducing the reactions for the various conditions, by steps we get

$$R_1 = \frac{WB}{2L} + \frac{(T + T_1)h}{2rL} + \frac{T + T_1(r - Q)}{2lr}$$

$$\text{and } R_2 = \frac{WB}{2L} + \frac{(T + T_1)h}{2rL} - \frac{T + T_1(r - Q)}{2lr}$$

It will be seen that if Q be equal to r the reactions R_1 and R_2 are also equal and if Q is on the centre line of wheel axes or $Q =$ zero then

$$R_1 = \frac{WB}{2L} + \frac{(T + T_1)h}{2rL} + \frac{T + T_1}{2l}$$

$$\text{and } R_2 = \frac{WB}{2L} + \frac{(T + T_1)h}{2rL} - \frac{T + T_1}{2l}$$

whilst for the condition wherein the front driving wheels are about to slip R_1 and R_2 become

$$R_1 = \frac{WB[l + 2\mu(r - Q)]}{2[lL + \mu L(r - Q) - \mu hl]}$$

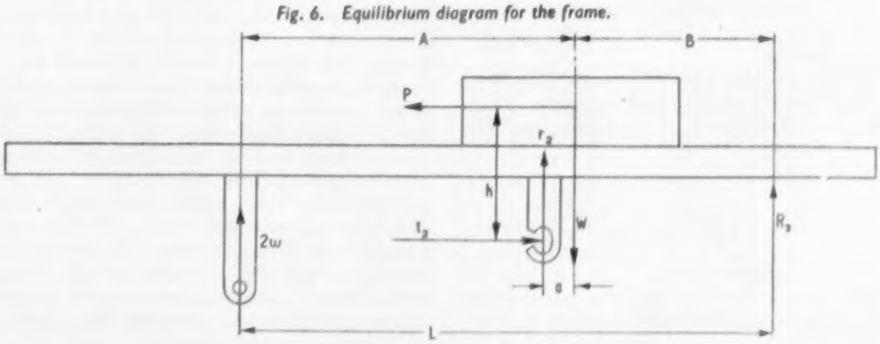
$$R_2 = \frac{WBL}{2[lL + \mu L(r - Q) - \mu hl]}$$

whilst the total slipping torque will equal $2\mu r R_2$ but if the torque is not equally shared between the two axles the total slipping torque will be

$$T \text{ slipping} = \frac{WB\mu r}{L - \mu h}$$

If both pairs of driving wheels are about to slip, reactions

Fig. 6. Equilibrium diagram for the frame.



will be expressed as

$$R_{1,2} = \frac{WB[l \mp \mu(r - lQ)]}{2l(L - \mu h)} \quad \text{where negative sign} = R_2 \text{ and positive sign} = R_1$$

If the condition occurs wherein the front driving axle has a tendency to lift when R_2 = zero R_1 becomes

$$R_1 = \frac{WB(r + Q)}{L(r + Q) - hl}$$

$$\text{and total lifting torque} = \frac{WBrl}{L(r + Q) - hl}$$

There is still further adjustment of reactions in the case wherein the torque is used to accelerate the driving wheels, and it will be noted that it is independent of the dimension Q,

$$R_1 = \frac{WB}{2L} + \frac{T + T_1}{2l}$$

$$R_2 = \frac{WB}{2L} - \frac{T + T_1}{2l}$$

A somewhat similar type Fig. (b) is that in which the spring mounting differs insomuch as each spring is pivotally mounted at its centre to a fixed frame bracket; the spring eyes are attached to the axles by the same method as that of the previous design. This arrangement provides that torque reactions induce horizontal forces only in the springs, the vertical forces at the spring ends always remaining equal, so that

$$R_1 = R_2 = \frac{WB}{2L} + \frac{(T + T_1)H}{2Lr}$$

similarly when driving wheel acceleration and resistance is considered

$$R_1 = R_2 = \frac{WB}{2L} + \frac{T + T_1}{2L}$$

whilst the maximum torque to be applied before slipping occurs is limited by the tendency of all driving wheels slipping at the same time as the front axle lifts.

$$\text{thus } T \text{ max. slipping} = \frac{WB\mu r}{L - \mu H}$$

The next type to be considered is that usually known as the WD type, Fig. (c) and generally, although not exclusively, its use is confined to military vehicles. There are further developments of this design, one which immediately comes to mind being the Thornycroft type. This embodies a gimbal mounting for the axle attachment of the spring eyes, whereas the WD type incorporates large shackles which leave the axle casings free to rotate within the shackle centres. In consequence torque arms are necessary, since otherwise the casings, under the influence of torque reaction, would tend to rotate in a direction opposite to that of the road wheels. The spring centres are rigidly fixed to a trunnion bracket, pivotally mounted in turn to a fixed frame bracket. Incidentally, the W.D. design provides for lateral movement of the axles in relation to the spring shackles in order, (a) to relieve the road springs of a portion of the torsional loads experienced when traversing rough terrain, and (b) to provide some assistance towards better tracking and less tyre scrub when cornering.

It should be noted that the ground reactions are always equal, since the axle centres and the trunnion centre are on a common axis level when loaded, the reactions therefore

$$\text{are } R_1 = R_2 = \frac{WB}{2L} + \frac{(T + T_1)H}{2Lr}$$

$$\text{and they become } R_1 = R_2 = \frac{WB}{2L} + \frac{T + T_1}{2L}$$

when acceleration and resistance apply.

A type which is found on the Continent is the gear driven bogie, Fig (d) in which axle shafts revolve in the same direction as the wheels. Gears are mounted on the ends of the axle shafts with a casing containing the intermediate gear mountings, pivotally positioned on the ends of the axle casing. A combined torque tube attached to both axle centre and frame is often employed although the Hotchkiss drive is not unknown. Since the springs are the sole medium of attachment of the axle to the frame, the results will be similar whichever type of drive is employed. Equality of torque distribution is difficult to obtain in such a gear reduction train with a distribution over four wheels, and therefore the limiting factor to the magnitude of torque which can be applied occurs when all the driving wheels tend to slip, or—an unlikely event—the front axle lifts clear of the ground. If the ratio of rotation of axle shafts r.p.m. to wheel revs/per min. be N

$$\text{then } R_{1,2} = \frac{WB}{2L} + \frac{(T+T_1)(h+x)}{2Lr} + \frac{T+T_1}{2NL} \mp \frac{(T+T_1)(N-1)}{2Nl}$$

where positive sign in last expression $= R_1$, negative „ „ „ $= R_2$

If $N = 1$ then

$$R_1 = R_2 = \frac{WB}{2L} + \frac{(T + T_1)h}{2Lr}$$

whilst the torque which will lift the front driving axle is

$$T \text{ Lifting} = \frac{WBrNl}{rL(N - 1) - l(xN + r) - hlN}$$

$$\text{in which case } R_1 = \frac{(T + T_1)(N - 1)}{Nl}$$

In the condition wherein all driving wheels slip the reactions are represented by

$$R_{1,2} = \frac{WB[Nl \mp \mu r(N - 1)]}{2LNl - 2\mu[LlN + l(xN + r)]}$$

where positive sign in numerator $= R_1$, negative sign in numerator $= R_2$

and the max. torque

$$= T \text{ slipping} = \frac{WB\mu rNl}{LNl - \mu[hlN + l(xN + r)]}$$

As in previous examples, should the whole torque be utilised in overcoming resistance to the driving wheels or in accelerating them

$$\text{then } R_1 = \frac{WB}{2L} + \frac{T + T_1}{2LN} + \frac{T + T_1(N - 1)}{2Nl}$$

$$\text{and } R_2 + \frac{WB}{2L} + \frac{T + T_1}{2LN} - \frac{T + T_1(N - 1)}{2Nl}$$

these are all straight forward and conventional calculations. They serve to form a basis for static stresses on the chassis side members, whilst they illustrate how even the elementary reactions transmitted to the structure vary according to design selected.

Floatation of Vehicle

The foregoing presents an outline of some of the reactions to be borne in mind concerning the structure and ground loads when considering a new type of six wheeler bogie design, but of course other problems also exist. Cross country operation presents many design problems and provision is necessary against sinkage of tyres on each and all types of terrain encountered in different parts of the world. Consideration is demanded regarding the most suitable type of vehicle, the ground contact area of the tyre, its loading, and of course the traction obtained at the ground level. It does not follow that because a vehicle is successful on one type of surface that the same vehicle and equipment will perform equally well on an entirely different surface, neither does it follow that adequate traction is sufficient to ensure success if the terrain possesses dissimilar characteristics,

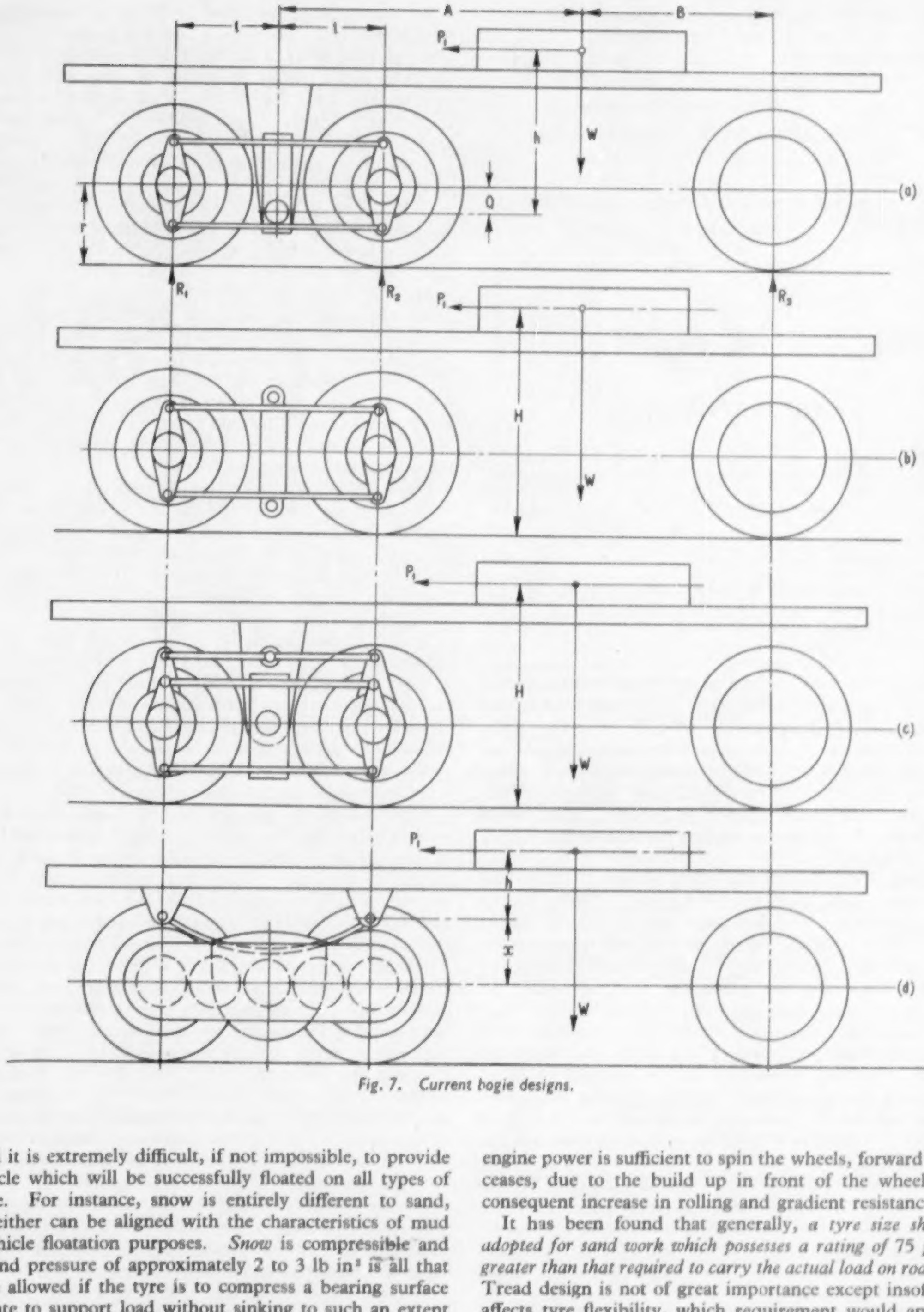


Fig. 7. Current bogie designs.

indeed it is extremely difficult, if not impossible, to provide a vehicle which will be successfully floated on all types of surface. For instance, snow is entirely different to sand, and neither can be aligned with the characteristics of mud for vehicle floatation purposes. *Snow* is compressible and a ground pressure of approximately 2 to 3 lb in² is all that can be allowed if the tyre is to compress a bearing surface adequate to support load without sinking to such an extent as to stall the vehicle, but *sand*, on the other hand (except when it is very wet) does not compress so readily. It can be likened to very fine round shot, the particles being displaced upon contact with the tyre, so that some particles roll to each side whilst the remainder compacts immediately under the tyre contact surface. When encountering soft sand tyre pressure (and all that that implies) is of paramount importance, as upon that depends intensity of ground loading and contact area, which if greatly in excess of 12/14 lb in² will probably permit sinkage to a depth which, although engine power is sufficient to spin the wheels, forward motion ceases, due to the build up in front of the wheels (with consequent increase in rolling and gradient resistances.

It has been found that generally, *a tyre size should be adopted for sand work which possesses a rating of 75 per cent greater than that required to carry the actual load on road work.* Tread design is not of great importance except insofar as it affects tyre flexibility, which requirement would appear to indicate a small number of plies, with tyres of single equipment, as twin tyres on a driving axle in sand can reduce performance by as much as 30 per cent when compared with normal ground performance.

In dealing with inflation pressures it must be said that tractive ability is improved by reducing the normal pressure. This procedure reduces rolling resistance, because it allows the tread to become concave (this avoids the wedge action of a hard tyre), and sinkage is not so deep. In addition sand is trapped over a wider area and adhesion is improved and

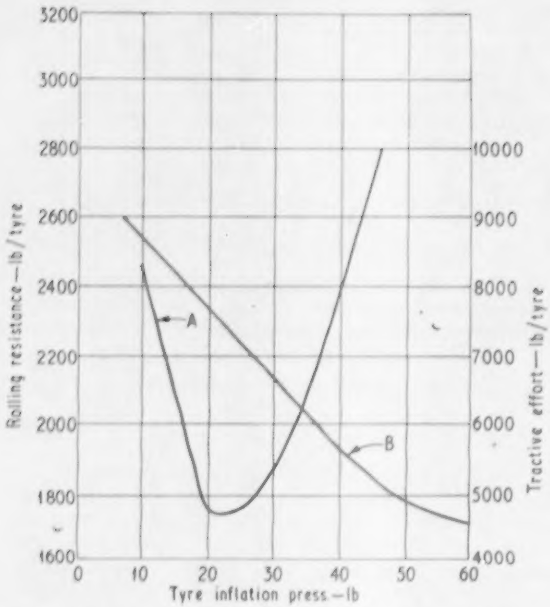


Fig. 8. Curves of rolling resistance A and tractive effort B.

advantage is taken of the full compressibility of the sand. Rolling resistance and tractive effort are both affected by tyre pressure, and the variations are true for most tyre sizes. With reference to Fig. 8, points to be noted are that as deflation increases tractive effort increases rapidly and rolling resistance approaches its minimum, until further deflation occurs when the curve again rises rapidly. The results shown in Fig. 8 were plotted under a pressure rating of 50 lb for normal loads.

A practical example of the effect of tyre pressure will illustrate the importance of this feature. A vehicle fully laden to tyre capacity for road work with 10·00 × 20 singles and say 70 lb pressure, was hardly capable of movement at all in soft sand dunes, and certainly not able to climb any gradient. Floatation was practically non existent. The tyre pressures were reduced to 40 per cent of their road rated pressures and the vehicle climbed a 14 per cent gradient comfortably, whilst also towing a load of 2500 lb. Even this was not considered satisfactory for the purpose on hand, and the tyre size was revised, 14·00 × 20 being fitted, with a rated load nearly twice that of the 10·00. With these revised tyres inflated to 40 per cent road rating pressures, the vehicle climbed a gradient of 30 per cent with a greatly increased tractive effort so that it hauled a trailer of 5000 lb gross. For soft ground the more driven wheels provided on the vehicle the better will be its performance, particularly with the heavy gross weight vehicle, since the lighter type of vehicle permits normal sand duties to be carried out simply by tyre adjustment.

The vehicle was a front wheel drive type of 40 tons gross (load equally distributed over each wheel). The rolling resistance of 11000 lb tyres 24 × 32 pressure 50 lb. This vehicle was capable of a level ground movement with draw bar pull of 2500 lb but gradient performance not all that could be desired. In this case the front driving wheels had to overcome not only the rolling resistance of the trailing axle but in order to exert the drawbar pull of 2500 lb had to be capable of producing a tractive effort of 2500 lb and 5550 lb = 8050 lb.

The rear axle was detached in the workshop and a four wheel drive vehicle produced by fitting an interchangeable driving axle, etc. The vehicle then still produced its 8050 lb effort plus the effort of the rear drive—another 8050 lb total 16100 lb, whilst part of the rolling resistance was eliminated as both axles were now driven. Gradient performance was considerably improved to a gradient of 15 per cent, and drawbar pull of 16000 lb on level sand. The drawbar pull was further improved by reducing tyre inflation pressure from 50 lb to 20 lb. This resulted in an increase of nearly 4000 lb. The use of large diameter tyres is desirable rather than those of larger section, since the arc of sinkage is longer with the larger diameter whereas the smaller diameter must sink lower to obtain a similar contact area.

Mud is an entirely different proposition, being more easily dispersed than sand, and therefore it does not have the same effect in deforming the tyre under reduced pressures. In consequence the advantages in sand are not experienced on a muddy surface, but the large diameter tyre is still advisable, with a tread designed to grip the terrain as soon as the consistency of the mud improves until the hard surface below is reached. Tyre diameter is important for other considerations of equal importance.

Snow traction is equally variable since traction in this case varies with the temperature, in fact a tyre which with a suitable tread design may give satisfactory traction at 0 deg F whereas as the temperature rises nearer to freezing point traction disappears altogether. It will be appreciated that under pressure the snow forms ice and tread grip is lost, hence the common use of chains.

It is important to realise that upon any type of terrain whereupon traction is low and where penetration or sinkage is above normal, the performance of the vehicle is limited by the amount of work the tyres can convert into tractive effort. Thus for the three cases mentioned of sand, mud, snow all wheel drive affords advantages, since regardless of engine power, forward movement may be impossible if *all* tyres do not contribute towards a share of tractive effort.

Reverting to the question of tyre diameter, it must be accepted that the effect of vehicle speed upon shock loading is that the amplitude of vibration varies inversely as the square of the tyre velocity but the frequency does not depend to such an appreciable extent upon velocity. The tyre will more effectively damp a vibration as speeds increase and as deflation increases (or the inflation pressure decreases). This suggests that the larger tyres with low inflation pressures are more desirable in the damping of vibrations, explained most probably by the fact that in a similar manner to the mechanical spring the tyre also has a spring "rate"—the load required to deflect the tyre a unit distance. The lower the pressure, the lower the "rate", and thus the road irregularities are more easily absorbed with less vibration. The significance of this is emphasised when considered in relation to the frequency of transference of road shock to the frame as it occurs on the six wheeler as compared with its four wheeled counterpart. (See early paragraphs).

Human tolerance of vibration also enters into the problem, particularly if public service vehicles are under consideration. Available data on this matter suggests that the frequency range lies between 1 to 60 cycles/min which may be divided into three further ranges; low frequency range 1 to 6 c/m $af^2 = 2$ = constant rate of acceleration change max; middle frequency 6 to 20 c·m rate of change $af^2 = \frac{1}{4}$; and the high frequency range 20 to 50 c/m with a change max of $af = 1/60$. Current design shows that general practice falls within the low range of 1 to 6 cpm on most vehicles purported to be used for passenger carrying. The mathematical conception of complete vehicle vibration is somewhat complicated, particularly with the rising popularity of the employment of rubber components, but as will be appreciated, most vehicle vibrations emanate from extraneous sources, generally excited by road irregularities.

Braking

It has been stated that braking of the bogie is more efficient as there is little or no transfer of weight as between one wheel and another, or that all wheels are similarly laden. A few closing words therefore will not be out of place. Assume air pressure is employed in brake operation, as is the case in most of the present day "heavies". Over the years many obstacles have required negotiating, one of the most important being that of *time lag* between application and actual operation. In part this may be due to air friction in the pipe line, and "wire drawing" effect. It may also arise from the inclusion of elbows, adaptors, etc., which may be inserted in the interests of assembly or replacement convenience. These may be important as regards costs but they can have a decidedly deleterious effect upon the efficiency of the whole system. This can be more full appreciated when it is known that the inclusion of even three right angle elbows in the line is equivalent to lengthening the pipe by 1 foot (which would present additional surface for air friction and change the direction of flow). This affects the time lag in the general pipe line.

Moreover it is established that not all the pressure in the system is available for braking, for instance at least 5 lb in^2 is required to overcome the inertia of the pistons in the brake cylinders, the brake shoe cam, and to move the shoe to take up its running clearance. Another important factor in estimating performance is the inclusion of a brake factor "K" which represents the ratio of weight on the braked wheel to the total gross weight of the vehicle. It will, therefore, be noted that accurate forecast of air brake performance is difficult without knowledge that all wheels are evenly braked, or all wheels are equally loaded.

A reliable prediction may be made using the following expression:—

Where V = vehicle speed m.p.h.

T = Time (from instant of pedal movement to the point of instantaneous application (Secs) (Air application time = 0·40 secs)

P = Brake chamber pressure (60 being the basic comparison figure).

K = Brake factor = $\dfrac{\text{Retarding force at ground}}{W \text{ of vehicle.}}$

E = Efficiency of system %.

A = Brake cyl. area (sq in).

F = Lining coefficient friction.

L = Slack adjusted length.

Rd = Brake drum radius.

Rc = Brake cam radius.

W = Weight on ground per wheel braked.

S = Stopping distance (ft).

$$S = (1{\cdot}467\ VT) = \frac{2WV_2}{30\left(\dfrac{P}{60} \times K \times E \times Wc\right)}$$

Where Wc = Calculated gross weight upon which K is based.

$$= \frac{A \times L \times P \times 2 \times F \times Rd}{Wx \times R \times Rc}$$

Comparative figures for time lag are;—

Period	*Driving Wheel*	*Trailer Bogie*
Pre-war	0·50 secs	0·74 secs
1954	0·31 secs	0·43 secs
1956	0·23 secs	0·30 secs

The last figures it will be noted show a decrease of over 50 per cent in time lag since 1939. They are based on the following facts:—

(a) Drivers perception reaction time 0·45 secs.
(b) Air application time (pipe loss, etc.) 0·40 secs.
(c) Vehicle is an 8 wheel articulated combination.
(d) Pipe dimensions which are important:—

(i) Reservoir to compressor	..	$\frac{3}{4}$in o/d.
Compressor to Brake Valve	..	$\frac{3}{8}$in i/d.
To Front Brakes ..	..	$\frac{3}{8}$in o/d.
To Rear Brakes	..	$\frac{1}{4}$in o/d.
Trailer Reservoir to Relay Valve		$\frac{1}{2}$in
Cylinders to Rear Brakes	..	$\frac{3}{8}$ in i/d flex. hose

CORRESPONDENCE

REAR ENGINES

SIR,—Being always most interested in reading the leading articles in the *Automobile Engineer*, I was surprised to find in the April issue an emphatic "No" in answer to the question as to whether a change from the conventional layout of cars would lead to greater export.

Whilst the drawbacks, which are quoted, of oversteer characteristic and insufficient luggage room in rear engined cars were real enough in the past, it is not the case with the latest models, for reasons which are now evident.

It is also clear to me that Renault could have easily reverted to the conventional arrangement had their experience with the 4 CV rear engined car justified the move for the new Dauphine. A large amount of standardization of components common to both models would still have applied to a new front engined vehicle except for the separate casings and additional parts needed; but instead of the 13 ft long Dauphine's weight being under 12½ cwt, it might well have reached that of the shorter and less roomy equivalent conventional car, which is in my view more costly to make and to run. Besides this saving in weight and cost, the rear engined car has the further advantage of increased adherence of the driving wheels similarly to the "*Tout a l'avant*" disposition.

To increase body space in relation to overall car dimensions, which is essential today, does not appear to me to generally depend on the rear as against the front location of the power unit. The length of the latter with its cooling system is at present the determining factor.

If the necessary knowledge and ingenuity were to be found to conceive a power unit small enough and demanding no more attention than that of the average refrigerator, it would be possible to locate such an engine in yet another unconventional position to then allow the passengers and their luggage to utilize the full length of the car.

GEORGES ROESCH, M.I.Mech.E.,
M.S.I.A., M.S.A.E.

SIR,—Your leading article in the April issue debunking the rear engine is both timely and to the point. An additional point against the rear position for the engine of particular importance in the design of vehicles for export, which you do not mention although it adds force to your concluding remarks, is that this is the worst possible position for dust. A further disadvantage of the type of installation used in the Continental cars to which you make reference is the severe limitation placed on the design of the rear suspension.

Despite the observations in your leading article, I notice from your review of the Renault Dauphine that the weight distribution in the unladen state is worse than 40 : 60, front to rear. From the arrangement drawing it appears that this is unlikely to be improved by the addition of passengers unless a substantial weight of luggage or ballast is also carried in the front boot. The ratio is almost exactly the inverse of that for the Ford Zephyr and Vauxhall Velox, two of Britain's most successful export cars, although the excellent handling characteristics of these vehicles are obtained at the expense of a certain lack of traction. The best of both worlds can be obtained with front wheel drive, although in the latest Citroen, which is so front-heavy as to require a different tyre size front and rear, this line of thought has been carried to something beyond a logical conclusion.

GAVIN P. B. MARTIN

(*Quot homines . . . . Ed.*)

HEAT TREATMENT EQUIPMENT

Recent Interesting Developments

DURING the past year Electric Resistance Furnace Company Ltd., Netherby, 161 Queens Road, Weybridge, Surrey, have been responsible for the development and introduction of heat treatment equipment for a variety of applications. In conjunction with their associates in the United States of America, Lindberg Engineering Company, they have developed a completely new design of heating element for electric furnaces. It is designated the Corrtherm element, and is claimed to mark a major advance in the science of heat treating metals.

High thermal efficiency and cleanliness have always been important advantages of electric heating, but probably the main factor responsible for the early progress in controlled atmosphere heating in electric furnaces was the absence of combustion products within the furnace chamber. In contradistinction to fuel-fired furnaces, it was not necessary to incorporate a mufflle between the heat source and the work. However, with the introduction of gas carburising and carbonitriding the electric furnace lost this advantage, since owing to the effect of rich hydrocarbon gases on the heating element material, it became necessary to incorporate an elaborate sealed metallic muffle or retort. This reduced the thermal efficiency and increased maintenance costs. The introduction of the Corrtherm element has reversed this tendency, because the element is unaffected by carburising gases and therefore there is no need for a sealing baffle.

Corrtherm elements are sheets of corrugated nickel chromium which practically cover the entire walls of the furnace. These sheets are hung from alloy hooks extending through the roof, an arrangement that makes installation and replacement very simple. Neither supports nor hangers need be built into the walls. The corrugations give strength, greater length and therefore greater resistance, and can be spaced to vary the heat release along the length of the furnace to compensate for heat losses through the door or from incoming cold work. The greater surface area results in lower surface temperature and longer element life.

Carbon deposition cannot, of course, be prevented in gas carburising furnaces, but the voltage in the furnace is so low that leakage through such deposition is impossible. Actually the oxide coating that forms on the surface of the element is sufficient to confine the current to the element even when covered with soot. In addition, a high temperature enamel is fired on the element.

In forced convection furnaces where high temperature fans circulate the atmosphere through the charge, the elements act as a direction baffle, heating the atmosphere at the same time. These elements have several advantages in the construction of large furnaces. They can be hung not only adjacent to the walls, but can be suspended in the heating chamber itself. For example, on multiple row pusher furnaces, the elements can be suspended between rows of work to give faster and more uniform heating. If desired, different temperatures can actually be applied in the several rows of work. A standard carbonitriding furnace with Corrtherm heating elements is shown in Fig. 1.

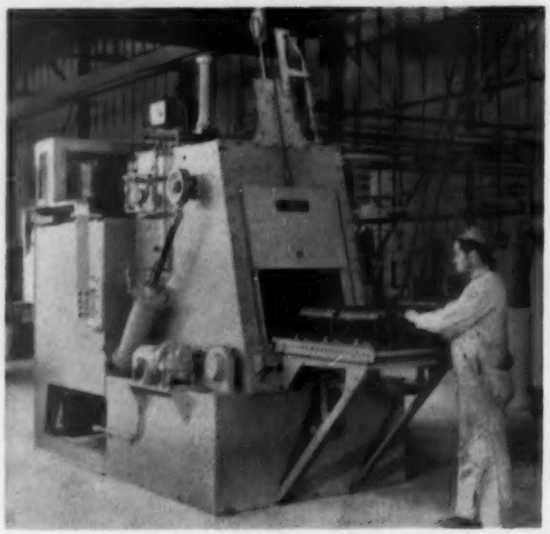


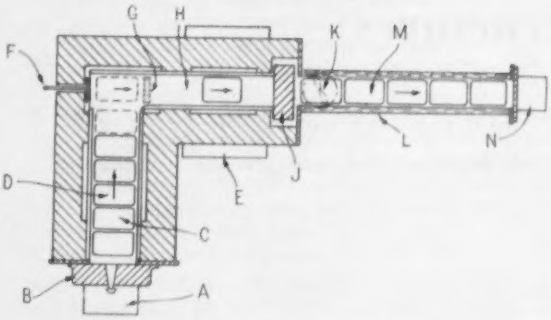
Fig. 1. Standard carbonitriding furnace with Corrtherm heating element

High speed steel furnace

An EFCO-Lindberg " L-type " furnace specifically developed for hardening high speed precision tools with cutting edges that cannot be ground or cleaned after hardening is illustrated in Figs. 2, 3 and 4. It consists of three sections, pre-heat, high heat and quench, all built in to one complete unit as shown in Fig. 4. The work enters the

Fig. 2. Operator pushing tray into high heat chamber

Fig. 3. Finished work being drawn from the cooling chamber



A—*loading platform*
B—*front door*
C—*trays in pre-heat zone*
D—*pre-heat zone metallic element*
E—*globar terminal box*
F—*high heat pusher rod*
G—*auxiliary door*
H—*high heat globar element*
J—*intermediate door*
K—*fan*
L—*water jacketed cooling chamber*
M—*trays in cooling chamber*
N—*discharge platform*

Fig. 4. Plan of EFCO-Lindberg "L-type" furnace for high speed steel

furnace cold and does not again contact the air until it is hardened and quenched. An unusual feature of the design is that the pre-heat section is built at right angles to the high heat section. The quench unit follows directly behind the high heat unit and is designed to quench the steel by means of forced convection, cooled, protective atmosphere.

In the pre-heat zone, the heating elements are of the metallic type, but in the high heat zone they are of the non-metallic type. Throughout both zones the hearth plates are of the non-metallic type which will not warp or melt in the high heat zone, but provide excellent heat transfer. The temperature in both zones is automatically controlled.

Tools to be hardened progress through the furnace in trays. The pre-heat section holds five trays, the high heat section one tray, and the quench five trays. To ensure that there will be freedom from discoloration, the work is cooled to below 200 deg C before it is removed from the quench and cooling chamber. Progress of the trays through the furnace is effected manually. In operation a tray of work is placed in the vestibule of the pre-heat zone just inside the charging door. At the end of a period appropriate to the size of the work, the operator by means of a built-in pusher rod, pushes the work from the high heat zone into the quenching zone. This is done after opening the intermediate door between the high heat and cooling sections. The operator then opens the charging door and pushes the last loaded tray to the transfer section which is directly in line with the high heat zone. Another tray is pushed forward into the pre-heat zone, to push all trays one stage forward. The front door is then closed and the operator goes to the pusher station, charges the pre-heated tray into the high heat zone, and then removes a tray from the quench chamber to make room for the next tray. Endothermic atmosphere operating on town's gas is recommended for this process.

Continuous brazing and bright annealing

A new design of wire mesh belt conveyor furnace developed by Electric Resistance Furnace Company Ltd. for bright annealing and copper brazing is shown in Fig. 5. Hitherto it has been common practice to use metallic type heating elements in furnaces for this sort of application, and the elements really operated above their safe maximum temperature range. Metallic heating elements of 80/20 nickel chrome normally operate at temperatures up to 1050 deg C, but when the furnace is used for copper brazing the required temperature in the furnace is in the order of 1120 deg C. and the element temperature approaches 1200 deg C. The new furnace has non-metallic type heating elements positioned above and below the belt. At copper brazing temperatures they are not forced to their full heating capacity of 1400 deg C, and are therefore not subjected to critical operating temperatures.

This furnace also incorporates a hearth of special articulated construction which allows the complete hearth assembly to breathe freely under temperature changes. Instead of metallic hearth plates, interlocked Carborundum sections are used. They give very long life, and if one section of the hearth eventually fails, it is not necessary to replace the whole hearth, but only the local Carborundum section.

In addition to the doors at the inlet vestibule and the outlet of the cooling chamber, intermediate doors are provided at each end of the heating chamber. These doors minimise heat and atmosphere losses. They can be closed down to a position just above the working height of the conveyor, and indicators are provided to show the door height above the conveyor level. The temperature of the cooling chamber is automatically controlled by aquastats in three or more sections. This eliminates wastage of water and ensures the correct cooling temperature cycle for the particular product that is being treated. If the weight of work put through the furnaces varies from bright annealing to copper brazing, then the water consumption is automatically adjusted. In the past it was often found that the operator would run the cooling chamber at maximum water rate, and when a lower temperature treatment was carried out, or weight throughout was reduced, water condensation would occur on the surface of the work, and discoloration would result. This is eliminated in this new furnace. Endothermic atmosphere is being used with many of these furnaces, and carbon steels can be brazed without fear of decarburisation.

Fig. 5. EFCO continuous blazing and bright annealing furnace

Plastics Structures

A Scientific Appraisal of the Knowledge and Experience Gained So Far and an Indication as to the Directions in Which Further Progress May Be Made

PLASTICS materials are becoming increasingly popular for use in vehicle construction, notably for the bodies of certain types of commercial vehicle. In the private car field, the most successful example of a plastics bodied vehicle made in reasonably large quantities is the Chevrolet Corvette. At least one manufacturer, Viberti of Italy, is experimenting with structures made entirely of plastics; these are in the Golden Dolphin and CV15 Monoplast coaches. So far, the main obstacle to further developments with these materials has been the relatively high cost of manufacture. However, this can be offset to some extent by design to reduce the amount of fabrication necessary and, in any case, the cost is not high by comparison with that of panel-beating. The material has many outstanding advantages, notably light weight, anti-corrosive properties, high resistance to impact damage and ease of repair.

Before plastics, or for that matter, any other new material, can make much progress in automobile construction, it is essential to demonstrate to manufacturers that they can have confidence in the performance of the material throughout the useful life of the product made from it. In a paper entitled 'Plastics Structures', by G. C. Hulbert, B.Sc., published in the February 1956 Journal of the Royal Aeronautical Society, the author examines the experience and knowledge so far gained. He also isolates some of the factors that tend to hinder the growth of confidence, and thus indicates the lines on which more progress might be made.

Consistency of test results

In aircraft structures, where freedom from failures is a vital requirement, the factor of safety applied to plastics structures is approximately double that of the metal ones. This largely nullifies the strength/weight advantage of plastics. However, this is not such a serious disadvantage in motor vehicle construction, for Automobile engineers generally use factors of safety such that it is not necessary to design with such precision, so far as load-carrying capacity is concerned.

An examination of the reason for the adoption of a high factor of safety for plastics materials shows that it is because of the scatter obtained in test results. It is obvious, therefore, that the key to improvement is correct and full control of the manufacturing processes involved, so that the scatter is reduced and the strength of the material can be predicted more accurately. In highly competitive industries, such as motor car manufacture, it is also necessary that this control shall be effected without any appreciable increase in cost.

Control is probably not so easy with plastics materials, because many processes, operations and materials go into the formation of one moulding. On the other hand, with metal, control and test measures can be effected at a number of clearly defined stages, such as in the foundry, rolling mill and in the fabrication of the components. It is impossible with the reinforced plastics material to find a true equivalent to the raw material stage for metal sheet. Even a simple test piece of plastics is a structural alliance of at least two dissimilar components. Factors in the make-up, handling and processing together of the glass, asbestos or resin can affect the final performance of the structure. Only recently has the state of knowledge been reached when it is possible to recognise the key factors that must be controlled to ensure consistent behaviour of the final product.

With the asbestos phenolic materials, two or at the most three, are of practical interest to the designer. Because this number is so limited, each has been tested exhaustively in the three characteristic pressure/temperature moulding conditions commonly employed. Authentic and reasonably complete strength and performance data are therefore available to the designer.

The main problem appears to be in the production of resinated felts, having full consistency of fibre content and orientation. Once this has been solved, the conditions of temperature and pressure under which these felts are moulded ensure a good degree of consistency. This is because of the isolation from ambient conditions during the moulding process. Variations in ambient conditions, of course, are known to influence the properties of laminates made by contact pressure, particularly when polyester resins are used and curing is effected at room temperature by means of chemical catylists. With all fibre-reinforced materials, whether the reinforcement be glass or asbestos, the prime requirement for obtaining consistency is for control over resin type and content, fibre content and orientation.

With resin-reinforced glass fibre materials, wide choice of fibre pattern is available, and therefore little comprehensive data exists about any one individual combination. For this reason, there is a strong argument for limiting to a minimum the number of combinations employed; this would expedite development of control methods to obtain consistent test results, since it would reduce the amount of work necessary to obtain complete strength and performance data to cover the range of materials used.

To obtain consistent results with glass fibre polyester materials, it is necessary to control the make-up of the fibre bundles and, if a woven material is used, their weave. Moreover, the quality of size employed must be consistent. The method of removing the size, and the type of finish treatment, if any, must also be carefully regulated. It is essential that the resin shall be specified exactly and that the supplier can maintain consistency, from batch to batch, with regard to both make-up and behaviour. Another requirement is that the catalyst and accelerator or temperature used to effect the cure, and also the pressure, are carefully controlled. The efficiency of impregnation is important and, if a post-cure heat treatment is necessary, it must be faithfully repeated on successive mouldings.

Test results should be studied against the background of the method of testing and preparation of the sample. This is because variations in one or more of the conditions mentioned in the previous paragraph may lead to widely different results, despite the fact that nominally identical materials are used. When all these factors have been regulated strictly, variations have still been experienced, even in tests made in the same works or laboratory.

In a paper entitled 'Curing Properties of Polyesters', by B. Parking, read before the Society of Chemical Industry in 1955, the author attributes much of this variation to the degree of stability reached by the resin at the time of the test.

The factors that give stability are as follows:

1. Complete absence of residual free peroxide catalyst or other oxidizing agent in the cured resin.
2. Absence of unreacted styrene or other monomer in the cured resin.
3. Absence of relatively low boiling compounds, such as ester plasticizers. Dimethyl phthalate, for example, is frequently used as a carrier for either the catalyst or accelerator. This does not combine chemically with the resin and sometimes migrates out of the cured resin after a period of time.
4. The resin must be fully cured.

The employment of too little catalyst may lead to its expenditure before polymerization is completed. On the other hand, too much may leave a permanent residue of peroxide, which because of its reactivity, may have a harmful effect on the laminate when it is free to combine with external agencies during weathering. With regard to the second and third items listed, it is significant that all cold cured laminates subjected to a heat post-cure are noticeably more consistent than laminates not so treated. The unstable presence of impurities in the resin may give a misleading impression of instability.

Possibly, the degree of styrene evaporation that can occur in laminates is of greatest practical significance with regard to the fourth item listed. Factors that can readily and significantly effect the amount of styrene lost are unnoticed variations in workshop conditions, such as draughts, slight changes in temperature, or variations in surface area: volume ratio from component to component. If there is insufficient styrene left to carry out the whole cross linking function, the laminate may be affected in a variety of ways: these include the lowering of the thermal resistance of the material, alteration of its modulus, and the undermining of its mechanical resistance. It is of interest to note that the presence of thixotropic resin limits the styrene loss to the surface by preventing replacement, and thereby reduces by about 50 per cent the overall amount lost.

Permanence

It is important that the properties of the material are permanent, or, if when the material is exposed to certain conditions, some deterioration has to be accepted, such deterioration must be shown to be finite and it must be possible to forecast with certainty the rate of deterioration. All combinations of asbestos and resin appear to be reasonably stable after an initial deterioration. On the other hand, materials reinforced with glass fibres are not so consistent. The resins have been shown to be extremely stable and inert except in the presence of organic solvents, of strong alkaline or oxidizing acid conditions. It may be concluded, therefore, that the deterioration is mainly due to the characteristics of the glass fibre. Therefore the resin must not only perform its structural function, but also must protect the glass fibre from external influences. In current investigations of this problem, the emphasis is on finish treatment for the fibres, to allow proper adhesion of the resin to the glass. Considerable progress has been made, but the problem has not been entirely solved.

The first requirement is to establish whether the deterioration experienced with finish treated glass fibres is due to the original adhesion being incomplete and leading to the initiation of attack by moisture, or whether the adhesion breaks down either as a result or normal thermal and attendant dimensional change, or because of stress loading. Improvement of the bond alone may solve the problem if the deterioration is due to imperfect initial adhesion. On the other hand, if the bond initially is good, but subsequent break down occurs, the following questions must be answered. Does the break down occur between the resin and the finish, leaving the finish unable to prevent deterioration of the fibre? Does it occur between the finish and the glass; if so, is it due to weakness of the bond, or is part of the glass surface detached? Furthermore, is the break down due to unexpectedly high stress concentrations at the interface, possibly due to resin shrinkage, or are flaws in the fibre body or skin responsible? If the cause is found to be conditions of stress that the bond cannot reasonably be expected to carry, the critical value at which break down starts must be determined and physical means sought, by changes to the resin and finish, whereby the load pattern is improved. Should research show that conditions are such that adhesion can never be fully effective, efforts must be directed to finding an alternative method of protection.

So far as mechanical behaviour is concerned, the only significant improvement attendant upon adhesion is in the modulus in tension and bending. It is offset by a serious drop in impact strength; this alone is a good reason for searching for an alternative to adhesion as a method of improving these properties. Among the possibilities are: the development of a finish to form a self-sufficient surface coating, capable of protecting the fibres unaided by the resin, and examination of the construction and stress conditions in the glass fibre to see if there is any link between its high tensile strength and its apparent sensitivity to external attack. Possibly some compromise between strength and chemical resistance might be desirable.

Temperature resistance

Asbestos or glass fibres remain unaffected at temperatures that cause disintegration of the resin. So far as the effect of heat on the resin is concerned, two entirely different conditions must be considered. One is subjection of the material to a high temperature for a short time, and the other is a condition where a moderate temperature has to be resisted over a long period. For short periods under high temperature conditions, all fibre-reinforced materials behave exceptionally well and have marked practical advantages over certain metals. The low thermal conductivity and specific heat of laminates causes relatively slow penetration and therefore the effects of high temperatures applied for short periods are confined to the surface. The type and mechanical make-up of the resin has little effect on this characteristic. Temperatures in excess of 1,000 deg C are easily resisted in certain applications. However, if the period over which the temperature has to be withstood is sufficient to allow the heat to soak into a large proportion of the moulding, the properties of the resin become significant.

Under tensile loads, since the fibres play a prominent and immediate role, the resins may be subjected to temperatures that cause appreciable softening without serious deterioration of the strength of the laminate. On the other hand, under bending conditions, the load is largely carried uniformly by the resin to the fibres; with this type of loading or under compression, where failure can be caused by buckling, the acceptable load is directly related to the degree of softening of the resin.

Silicone resins are the best from the point of view of all-round thermal characteristics, but in the present state of development, both material and processing costs severely limit their field of application. With phenolic resins, in general, chemical deterioration sets in at about 200 deg C, but recently devloped phenolic laminating resins can be used at considerably higher temperatures. They are not so costly as the silicones, but processing calls for the application of pressures of 25–50 lb/in^2, and the pre-cure conditions must be carefully controlled, and during the actual moulding operations, provision must be made for some breathing to take place.

Epoxide resins are capable of withstanding similar temperatures, but whereas the phenolics soften but little before decomposition sets in, the epoxides are more like the poly-

esters in regard to this characteristic. A progressive increase in flexibility occurs as the temperature rises above 100 deg C. Developments in the last two years have led to a considerable improvement of cold catalyzed epoxide resins, which previously had been but little better than the polyesters. So far as the hot setting resins are concerned, moulding temperatures of 180–200 deg C generally give the best temperature resistance in the finished product.

Polyester resins, of course, are attractive because of their moderate cost, which is only a little greater than that of phenolic resins, and because of the simplicity of handling them. However, they soften at a relatively low temperature. Fundamental research is being carried out with a view to improving these resins. Some of the new monomers already available in the United States of America have increased the maximum temperatures permissible under tensile conditions to above 200 deg C. They have not, however, helped much in reducing the gap between that temperature and the initial softening point.

Another problem is that, with few exceptions, all resins behave much alike in the lower temperature range, no matter what their ultimate resistance is. Generally, slight softening occurs up to 60–70 deg C, and thereafter a steady decline takes place until a temperature is reached at which the loss is rapid. This temperature differs widely according to the material. Because laminates in tension are not so sensitive to temperature, it is usual to make the tests in bending.

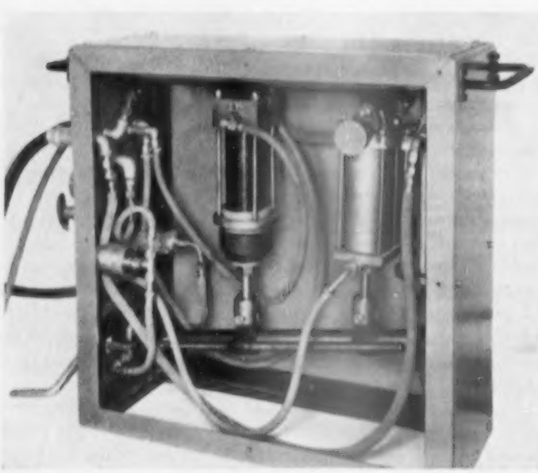
In the paper, the author goes on to describe the types of tests commonly used and the precautions necessary. He also includes a section on fatigue and creep. In the conclusion, he suggests that by concentration of effort within a framework, such as that covered by the paper, many of the doubts hampering the general acceptance of laminated plastics materials can be removed effectively and quickly.

SPRAY GUN EQUIPMENT

SPRAY guns are coming into use for an ever-increasing range of operations besides painting. One of the latest applications is the automatic spraying of lubricant on to press tools. It is claimed that with a press made by Hordern, Mason and Edwards Ltd., of Birmingham, used in conjunction with an automatic blank loading machine designed and manufactured by J. P. Udal Ltd., also of Birmingham, and equipped with an Atlas, type 30A automatic spray gun, rates of production of deep drawn pressings have been increased by as much as three times. The time required to set up the automatic blank feeding equipment and the Atlas grease sprayer is approximately half an hour, and the whole unit can be detached from the press in two minutes.

Another new development of Atlas Copco Ltd. is the new H3C, two-gun hot spray unit. This equipment is half the size and weight of the earlier H3B unit. The outstanding feature of the apparatus is that it can be used for hot spraying with two separate colours simultaneously. It has been designed primarily to overcome the wear problem associated with the use of heavily pigmented materials in hot spray equipment with gear type pumps in the fluid circuit. In the new equipment, the lacquer is not circulated to maintain a constant temperature; instead, the temperature between the heater unit and the guns is maintained by hot water circulated through a jacket round the paint hoses.

Interior of the unit for accurately metering resin and catalyst



The danger of leakage of hot water from the jacket is minimised because the water is taken through a small diameter pipe inside the jacket, to a point just below the gun and returns by gravity and displacement through the jacket. As a result, the pressure in the jacket is very low. Another advantage of this arrangement is that the hottest water is supplied to the end of the jacket nearest the gun, thereby ensuring that the temperature drop between the heater element and the gun is minimised. In fact, this drop is said to be not more than 1 deg. F. The unit incorporates a 2·7 kW heater, and the temperature is controlled by a thermostat that can be set to any position between 30 and 90 deg C (86 and 203 deg F).

During the last few years, certain finishes, incorporating resins of the urea-formaldehyde, polyester and epoxide groups, have been formulated which, applied in conjunction with a catalyst, produce a film that is hard and has extremely good wearing qualities. In addition, catalysts are used in conjunction with resins of the polyester and other groups, in the manufacture of glass fibre laminates. Hitherto, it has been necessary to mix the catalyst and resin in small quantities immediately before use, since chemical reaction begins immediately the catalyst is added. This is a disadvantage because of the labour involved in mixing the ingredients.

It has been apparent, therefore, for some years that there is a market for spray equipment capable of accurately and thoroughly mixing the catalyst and resin at the moment of atomization. For three years, Atlas Copco Ltd., in conjunction with some of the resin and paint manufacturers, have studied this problem. The outcome has been a new unit that will accurately meter the resin and catalyst, thoroughly mix them in their liquid form and finally atomize the mixed resin and catalyst in an even spray pattern.

The key component of the equipment is the dosing unit. This comprises three cylinders; one for catalyst, one for resin or paint and another for compressed air. The upper ends of these cylinders are mounted on a rigid horizontal bar. At the bottom, their pistons are connected to another bar, which is pivoted at one end. The function of the compressed air cylinder and piston is to move the bar about its pivoted end, and thus to actuate the pistons in the other two cylinders to eject the catalyst and resin into the feed lines to the gun. To regulate the relative quantities of resin and catalyst, the stroke of the piston in the catalyst cylinder is adjusted by moving the cylinder assembly nearer to or further away from the pivot of the lower bar. Thus, the proportions by volume of liquid ejected from the two cylinders are rigidly and accurately controlled.

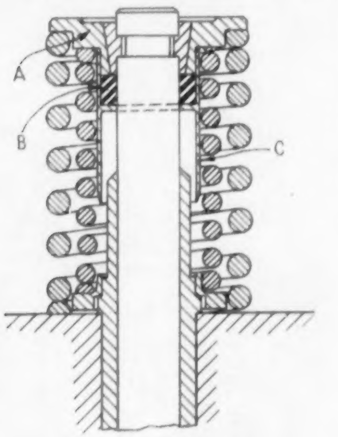
CURRENT PATENTS

A REVIEW OF RECENT AUTOMOBILE SPECIFICATIONS

Sealing valve stems

To stop the ingress of oil to the valve passage by way of the valve stem, both a sealing ring and a cover sleeve are used, it being suggested that individually neither is likely to be completely effective. Oil collecting on the valve spring retainer A is prevented from passing down the valve stem by a sealing ring B embracing the stem and abutting the lower end of the retainer. The sealing ring is supported by the transverse wall of the cover sleeve C which is fitted over the end of the retainer and soldered in position.

Preferably, the lower end of the sleeve is externally chamfered at an acute angle so that, in the event of the sleeve end being immersed as the valve is lifted from its seating, oil is diverted away from the valve guide. This chamfer also serves to identify the end and reduces the possibility of it being inadvertently soldered to the retainer. *Patent No. 733326. Daimler-Benz A. G. (Germany).*

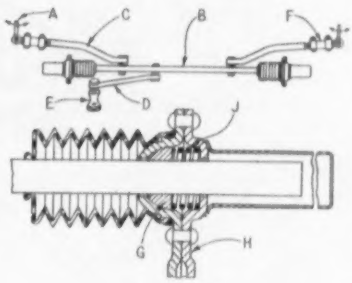


No. 733326

Steering Linkage

A FORWARD location of the engine, characteristic of modern chassis layout, is likely to create difficulty in the design of the steering linkage since the engine sump tends to interfere with the track rod. Such difficulty is accentuated as the track rod in commonly used linkages not only moves in reciprocation but must follow a path dictated by the arc of oscillation of the idling levers or links. In the present invention the track rod is supported directly from the frame and guided for straight-line reciprocation and therefore requires the minimum clearance through or around the engine sump.

As shown in the plan of the linkage, the steering arms A on the swivel heads are connected to track rod B by side links C and a drag link D connects the track rod to lever E of a conventional steering gear. Adjustment of toe-in is provided by couplings F in the side rods, though a single coupling in the track rod, intermediate the side rod connections, would suffice should clearance be available.



No. 734877

The polygonal track rod is supported in guide blocks G in hangers H rigidly secured to the vehicle frame. Guide block G, formed with a hemispherical face, is seated in a complementary pocket in the hanger and loaded by a helical spring J. It thus exercises a self-centering effect which prevents binding and eliminates rattling and also frictionally damps any tendency of the track rod to rotate about its axis. To prevent the ingress of water or foreign matter, a rubber or plastics bellows seals the track rod to the hanger on one side and a tubular metal casing encloses the protruding end of the track rod on the other side.

Since movement of the track rod is limited to reciprocation, the drag link may be connected at any point along its length and not necessarily between the connections of the side links, as shown. *Patent No. 734877. Thompson Products Inc. (U.S.A.).*

Seating arrangement for low-bridge buses

As the leading dimensions of a bus body are governed by standards, some difficulty is experienced in accommodating four passengers in a transverse row and also providing an adequate gangway. It is particularly pronounced on the upper deck of low-bridge type buses having a sunken gangway on the off-side of the vehicle. In the proposed arrangement, rows of four separate seats A mounted in a staggered relationship are provided. From the lateral gangway B each succeeding seat is located in advance of the preceding one and thus the occupant of each is independent of his neighbour. The shoulders of large-framed passengers can overlap without discomfort.

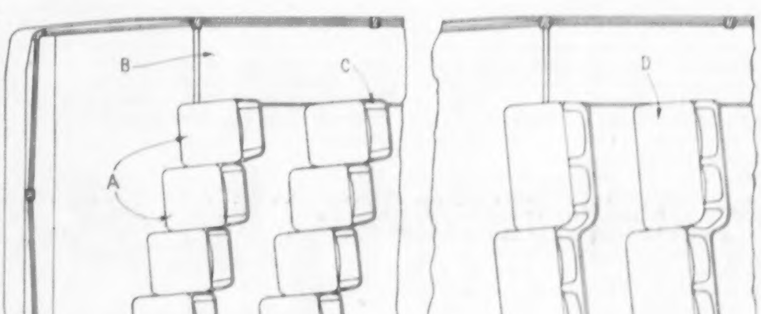
Seats are also set at a slight inclination away from the gangway. This feature ensures that all passengers, even the occupant of the seat adjacent the gangway, have a full foot rest. Seat backs may be shaped and have side wings C. Both seats and backs may be either individually or collectively mounted. In an alternative arrangement pairs of twin seats D are staggered and inclined in a similar manner

Although primarily intended for upper-deck accommodation, the layout can also be used for lower decks. The provision of coach-type seating on both decks renders a double-decker more suitable for touring than hitherto. *Patent No. 733081. West Yorkshire Road Car Co. Ltd. and H. N. Tuff.*

Running-in brake linings

NEW brakes or newly lined brakes are usually not wholly satisfactory in operation until the linings have been run in to the mating surface. The problem is not completely solved by milling or turning the assembled linings as the "bedding-in" effect is missing. To operate for a period in slave drums or roughened drums, either on a machine or the vehicle, is costly and time-wasting as it involves mounting, dismantling, and re-assembly. This Patent discloses a method of running-in which provides adequate braking effect during the running-in period and avoids the necessity for an additional operation or for removal and re-assembly.

Before assembly the drum is sand-blasted to raise small asperities on the operative surface. When the vehicle is run on the road the roughened drum ensures increased initial friction and rapidly wears down high spots on the linings. In so doing, the surface of the drum is simultaneously worn smooth and can be continued in service on the vehicle. *Patent No. 731788. Daimler-Benz A.G. (Germany).*



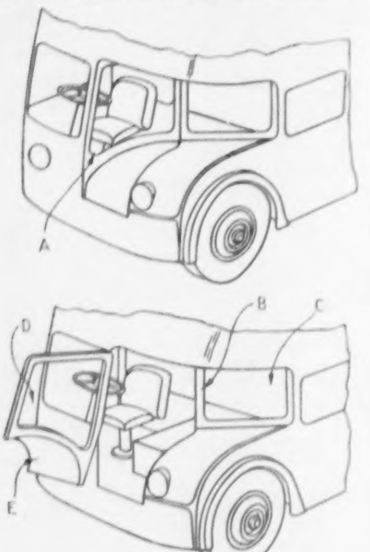
No. 733081

Cab for rear-engined double-decker

By a departure from the conventional half-cab the driver's range of vision can be improved on a rear-engined double-decker bus. There being no radiator or engine hood, the near-side wing constitutes the limit of the field of view. Instead of the near-side window running directly from front to rear in alignment with the longitudinal axis of the vehicle, it is set at an angle, approximately 45 deg, and extends from the centre of the front end to the near-side front corner of the saloon.

If the usual access door to the cab is retained on the off-side, the near-side window may be fixed and the fore end of the vehicle may follow the curve of the wing. Advantage may be taken of this curvature to allow the window to dip towards its front end, as at A, to give a view close to the vehicle.

Alternatively, the window may be divided by a pillar B to form a fixed window C and a front window D which, together



No. 733107

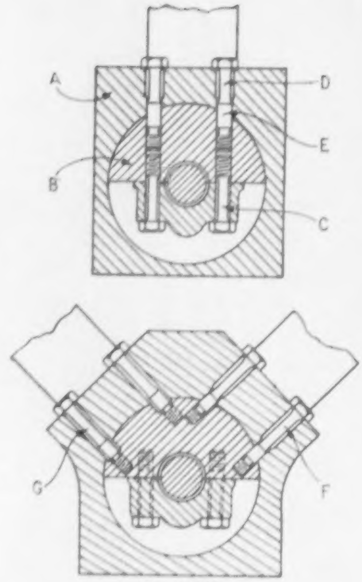
with a front panel E, is hinged upon the mid-line of the vehicle front to form an access door to the half-cab, as shown. *Patent No.* 733107. *Leyland Motors Ltd.*

Securing main bearings in tunnel crankcases

In a conventional arrangement common bolts are used to attach the caps to the bearing brackets and the brackets to the crankcase. Apertures must be provided in the crankcase to give access for assembly and such apertures serve no other purpose and must be subsequently sealed. The use of separate bolts for the two functions obviates this disadvantage.

Crankcase A and brackets B are machined with cylindrical mating surfaces. Bearing shells are seated in the brackets and secured by bearing caps and bolts C. Brackets and caps are assembled on the crankshaft, which is then threaded into the crankcase. Each bracket is secured to the crankcase by two bolts D which also serve to locate the bracket precisely by means of dowel portions E. Bolts C and D are in axial alignment and the holes to receive them extend completely through the bracket.

For V-type engines the bearing brackets



No. 735087

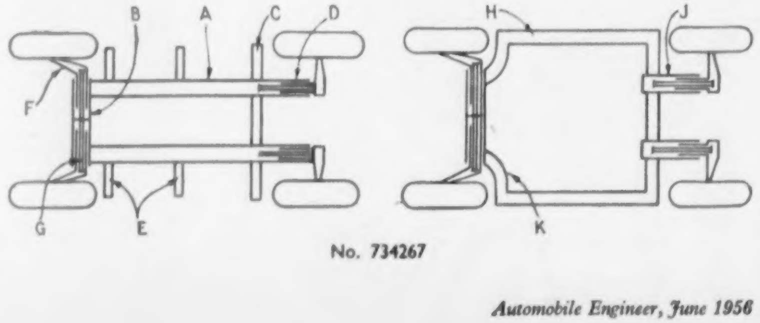
and caps are similar but two pairs of holding bolts are provided, arranged parallel to the axes of the cylinders. Only one pair, bolts F in the illustration, has a locating function while clearance is provided for the dowel portion of bolts G. Bolts F and G are staggered in respective transverse planes. *Patent No.* 735087. *Hannoversche Machinenbau A. G. (Germany).*

Torsion bar suspension

For a vehicle having all wheels independently sprung by torsion bars, a lightweight chassis frame comprising two longitudinal and two transverse members can be adequately resistant to torsional stresses providing it is short. The invention proposes a frame extending approximately from the rear edges of the front wheels to the forward edges of the rear wheels.

In its basic form the frame consists of two tubular longitudinal members A interconnecting rear cross member B and front cross member C, with free end portions D extending forward. Lateral brackets E are attached to the longitudinals to provide points of attachment for the vehicle body. The rear wheels are carried on cranked arms F bearing in the tubular cross member B and are sprung by torsion rods G consisting of a stack of leaf springs anchored at the centre of the cross member. At the front end similar springing arrangements are provided for the front wheels in the free ends of the longitudinal members. Spring anchorage in this instance is at the intersections of longitudinal and transverse members.

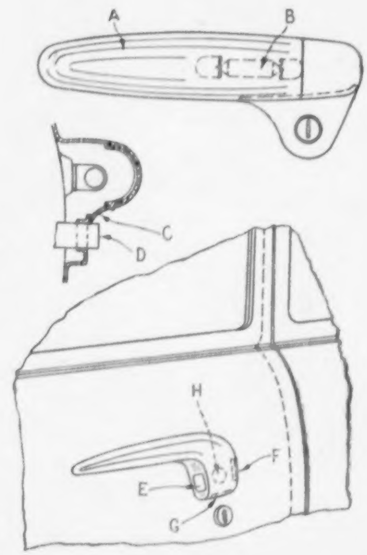
Alternative designs have inwardly swept and outwardly bowed longitudinal members, but a preferred form has discontinuous longitudinals H spaced out to the full width of the body. At the front they are closed by a cross member to which are attached the inset free ends J carrying the wheel arms and springs. The longitudinals terminate in front of the rear wheel and are joined to the rear cross member by arcuate connecting members K. *Patent No.* 734267. *Auto Union G.m.b.H. (Germany).*



No. 734267

Illuminated door handle

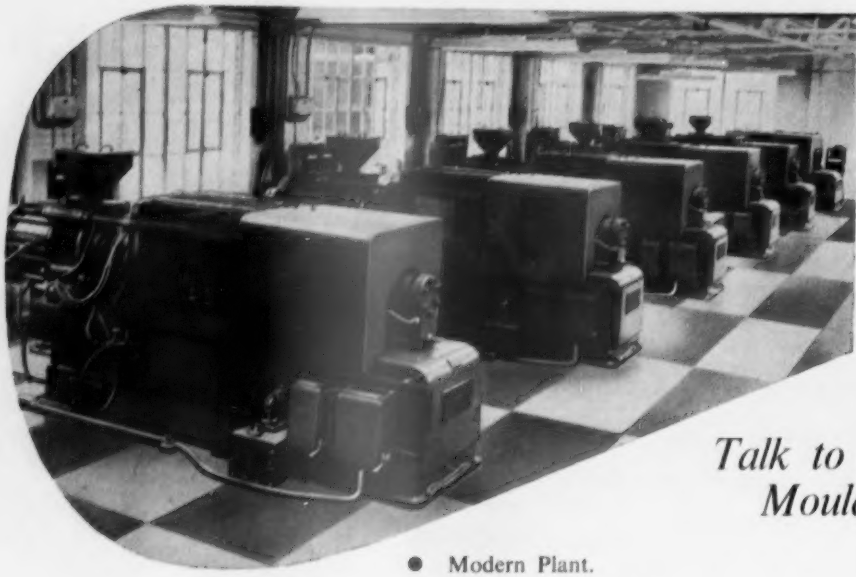
The outer part A of this fixed door handle is of translucent plastics material or glass and when illuminated by a lamp B therein serves as a parking light defining the lateral limit of the vehicle. In the lower wall of the handle, towards one end, is a transparent panel C which illuminates



No. 733295

the operating push-button D that incorporates the key slot.

In another embodiment of the invention the source of light is mounted in the base attachment part of the handle in which is mounted a clear transparent panel E facing forwards, a red transparent panel F facing rearwards, and a transparent panel G facing downwards to light up the lock. If desired, a further panel may be provided in the lateral face of the base part at H. If a two-filament lamp is fitted, panel H can be used for a blinking direction-indicating light. *Patent No.* 733295. *F. Porche (Germany).*



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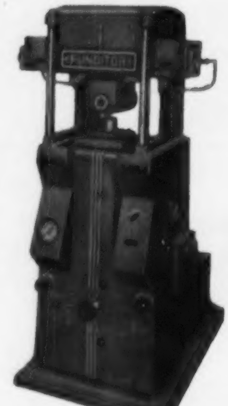

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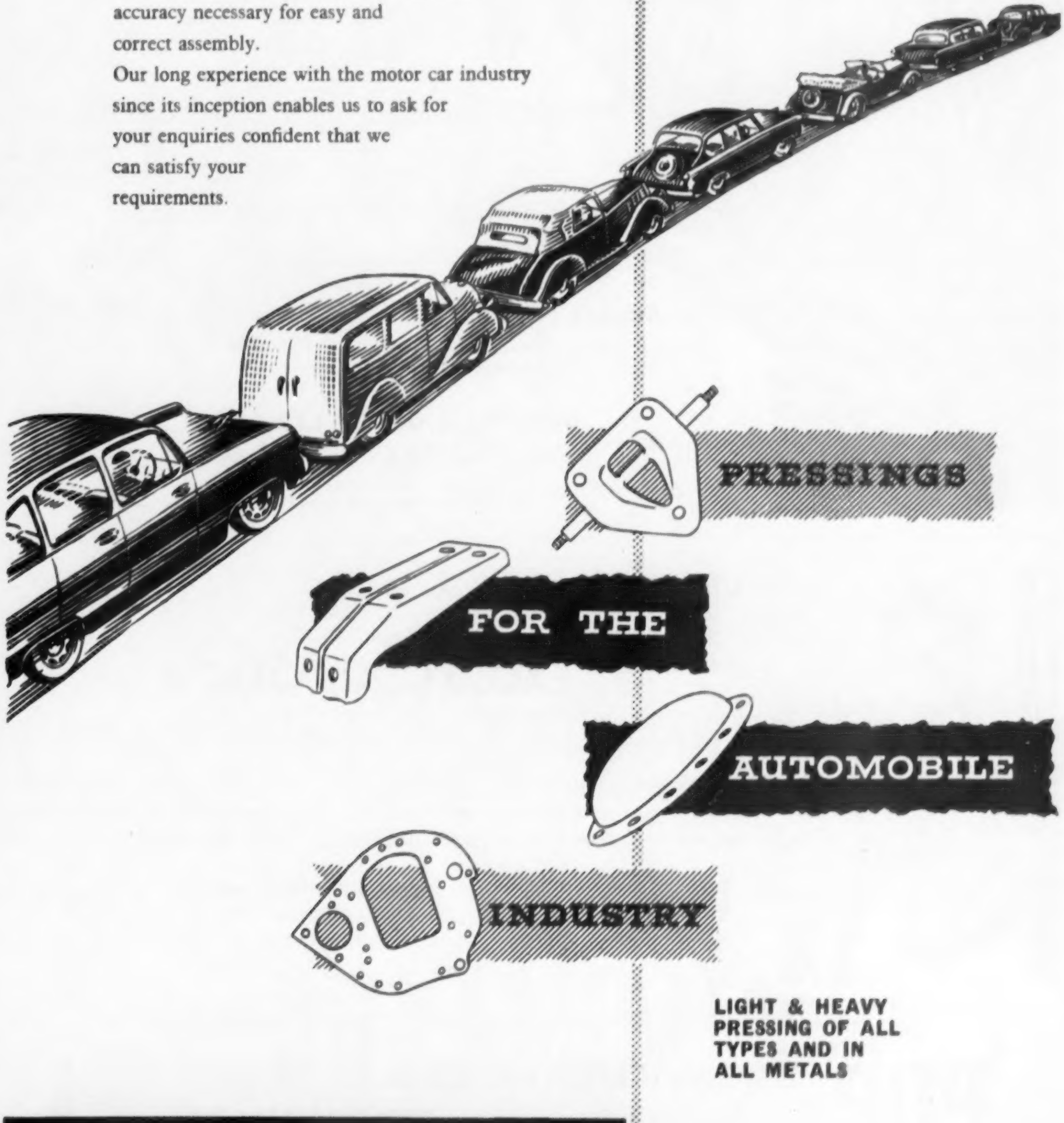

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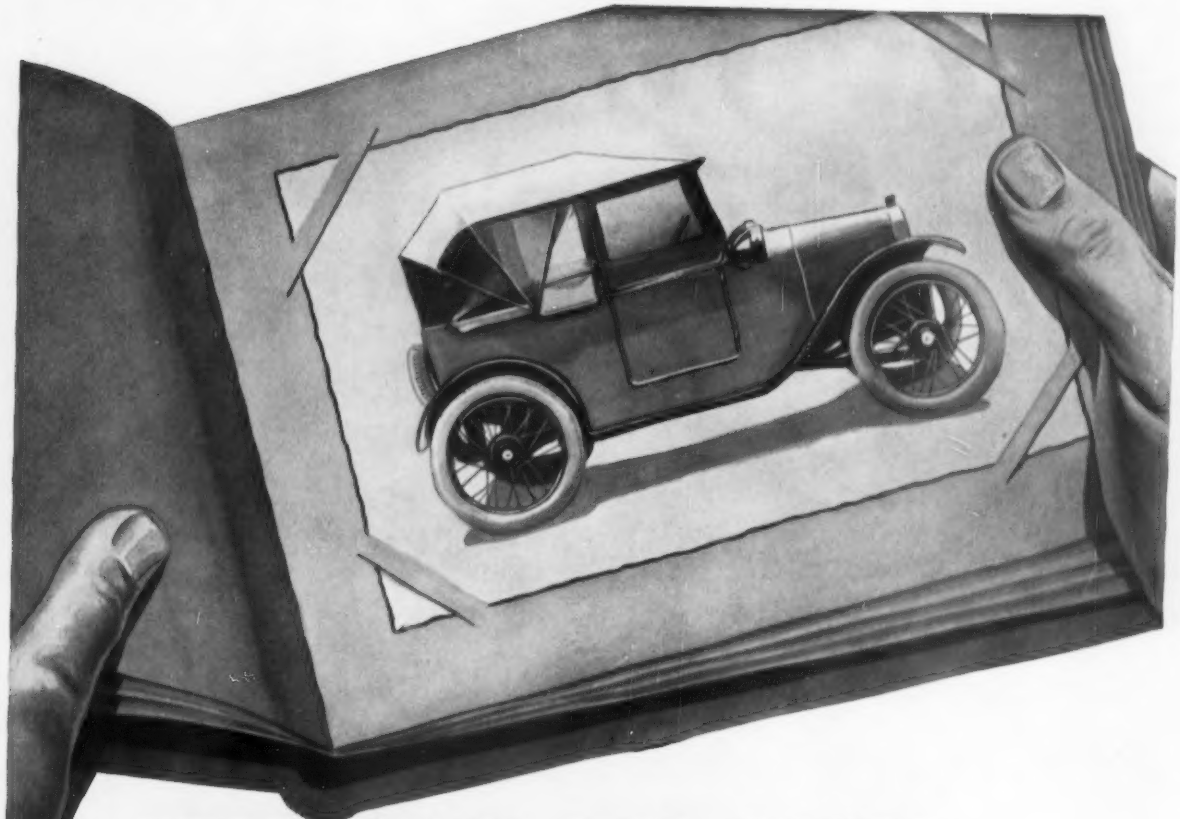

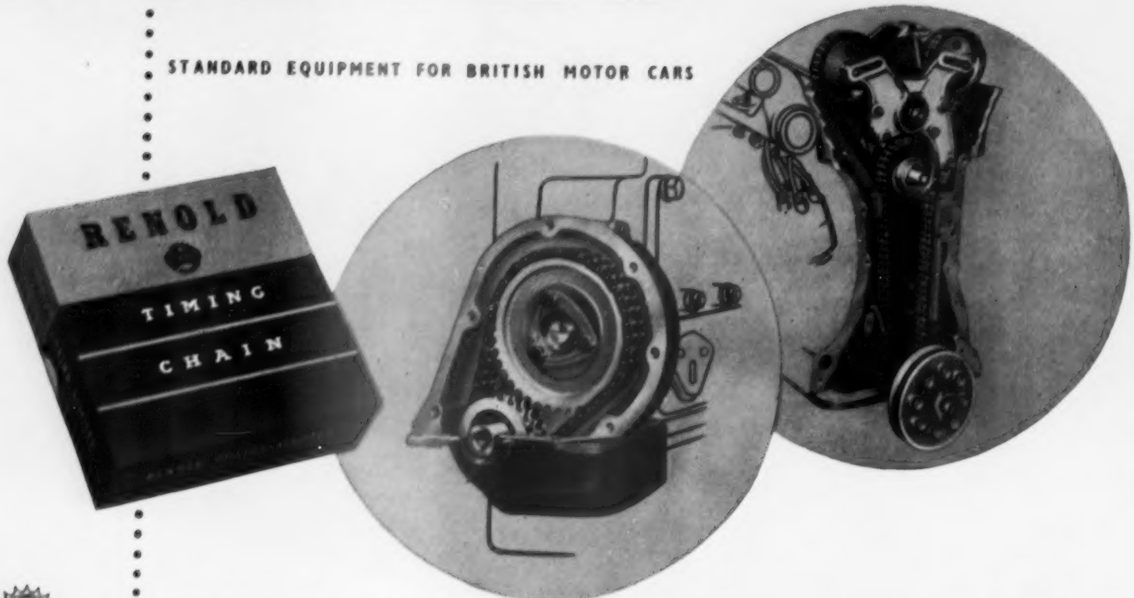

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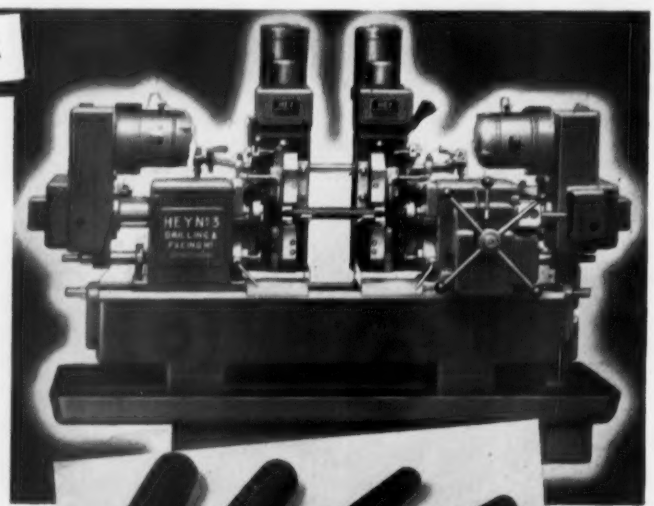

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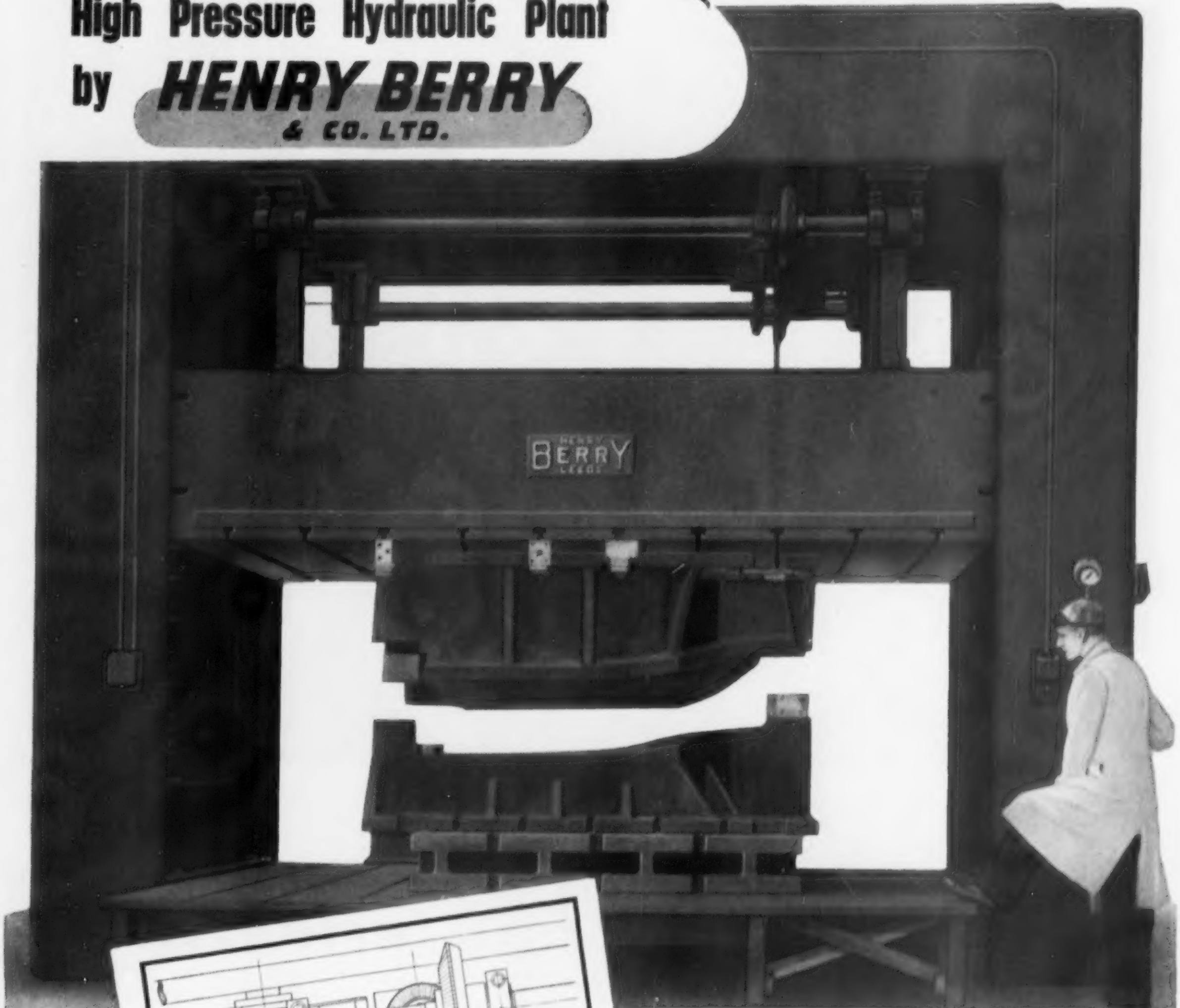

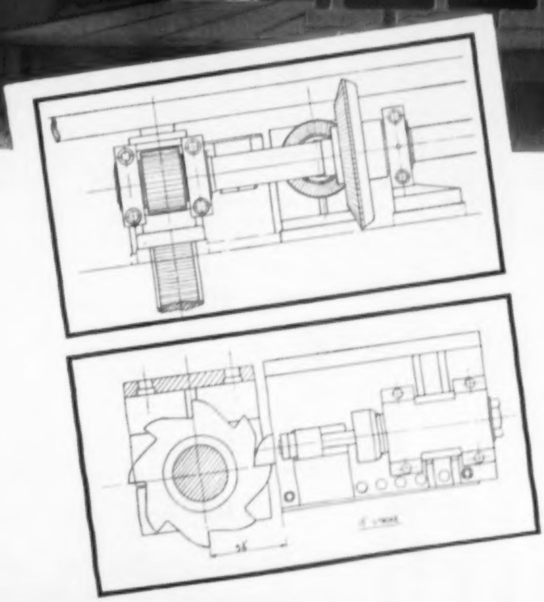

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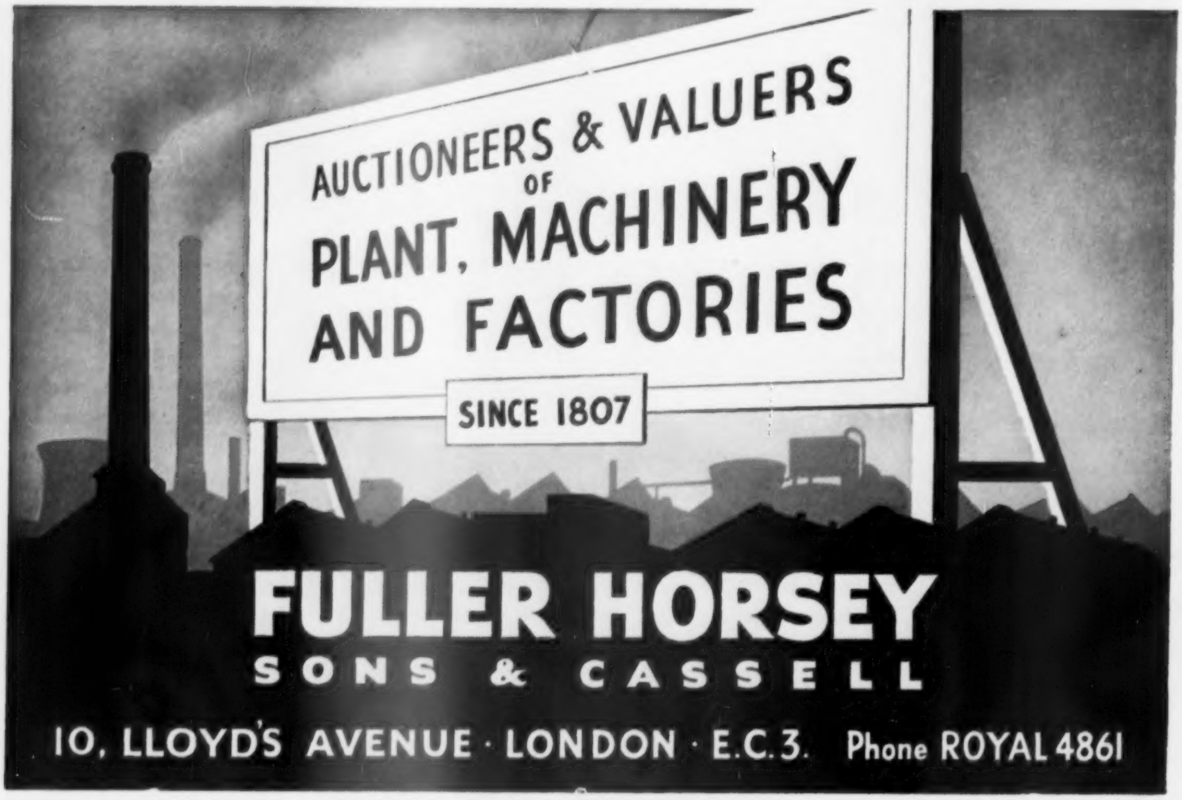
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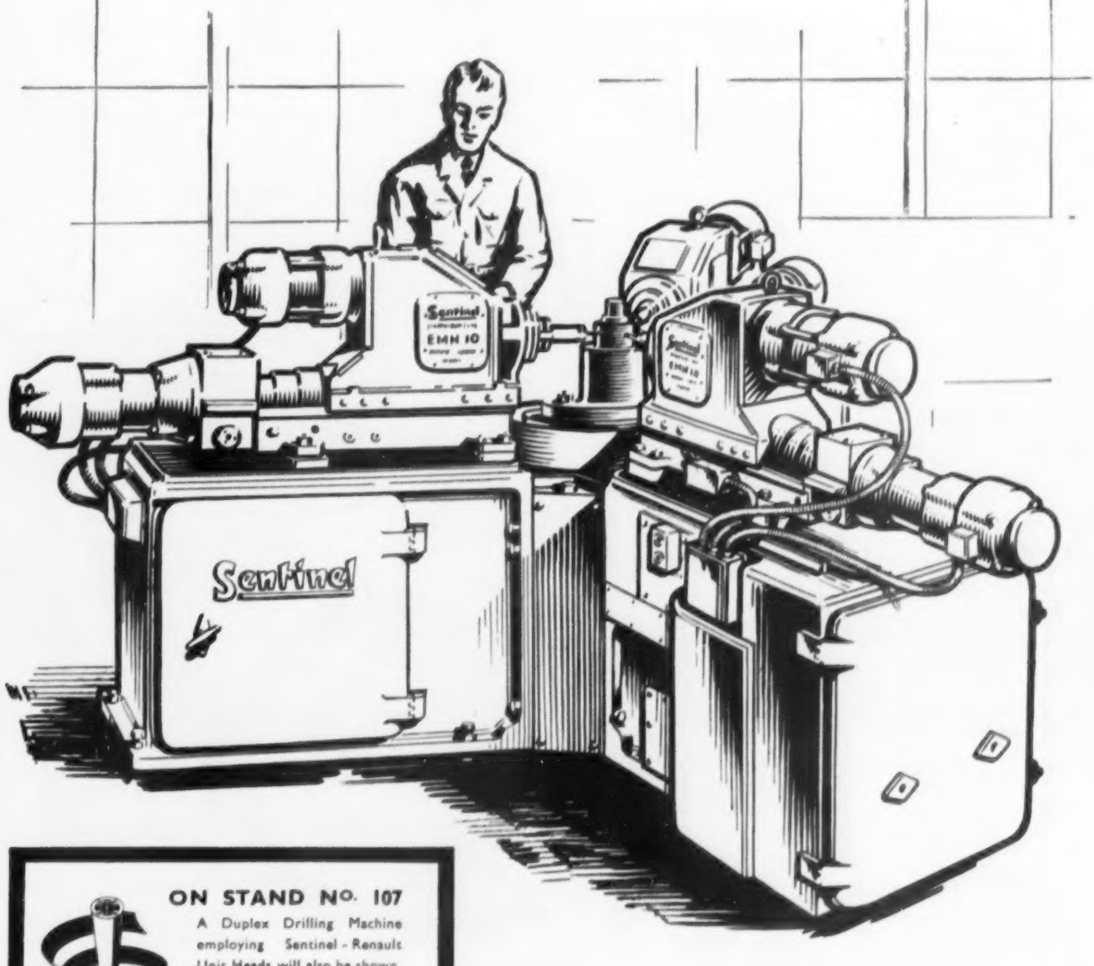

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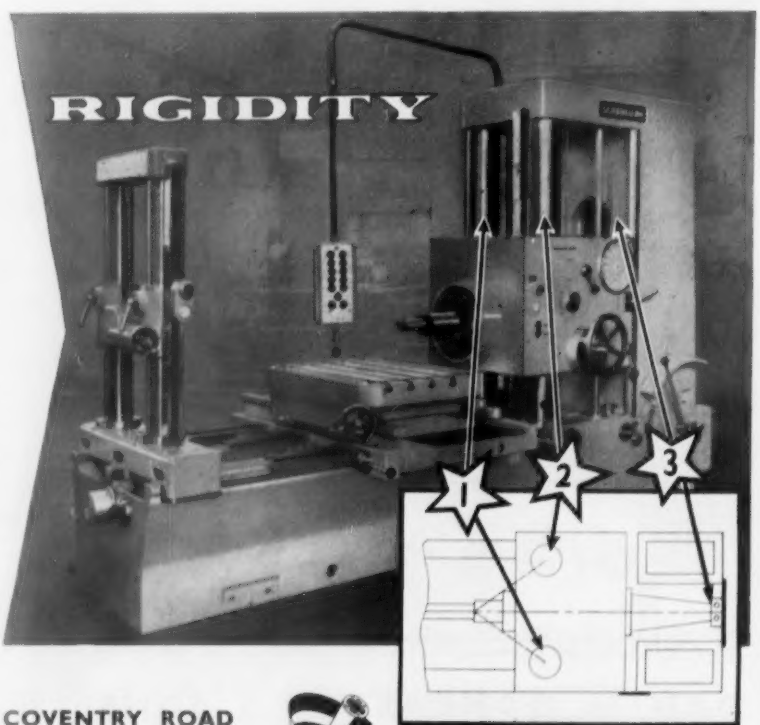

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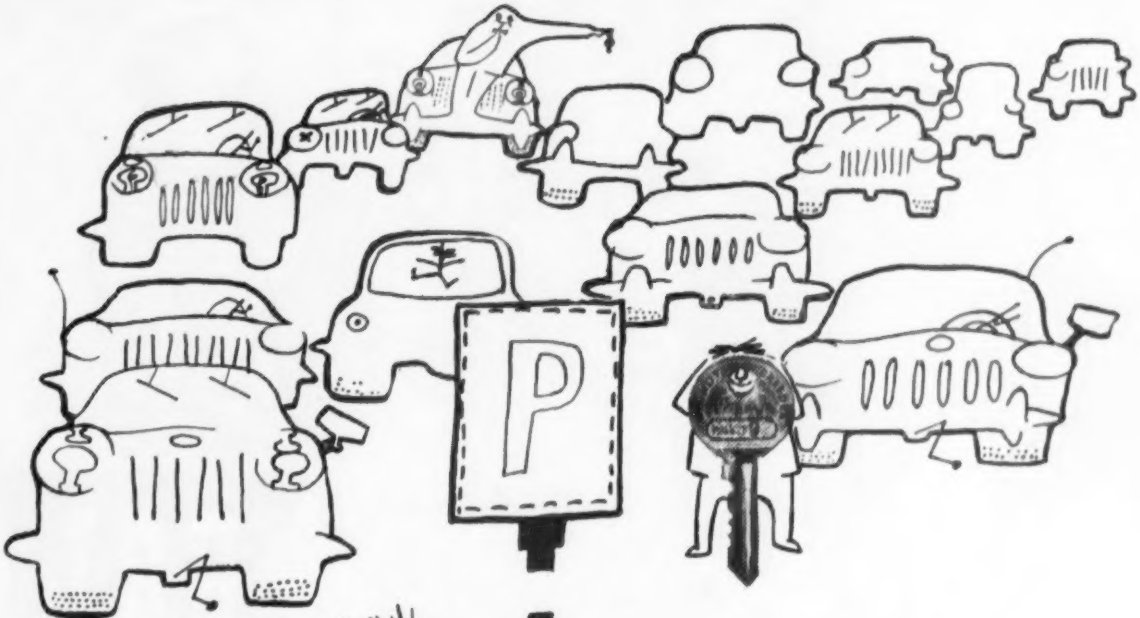
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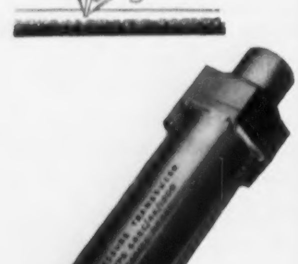

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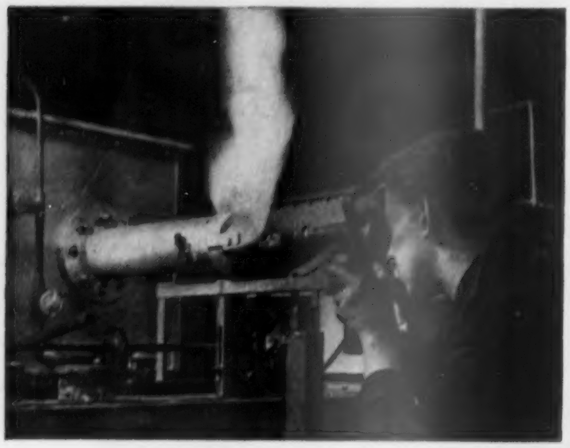

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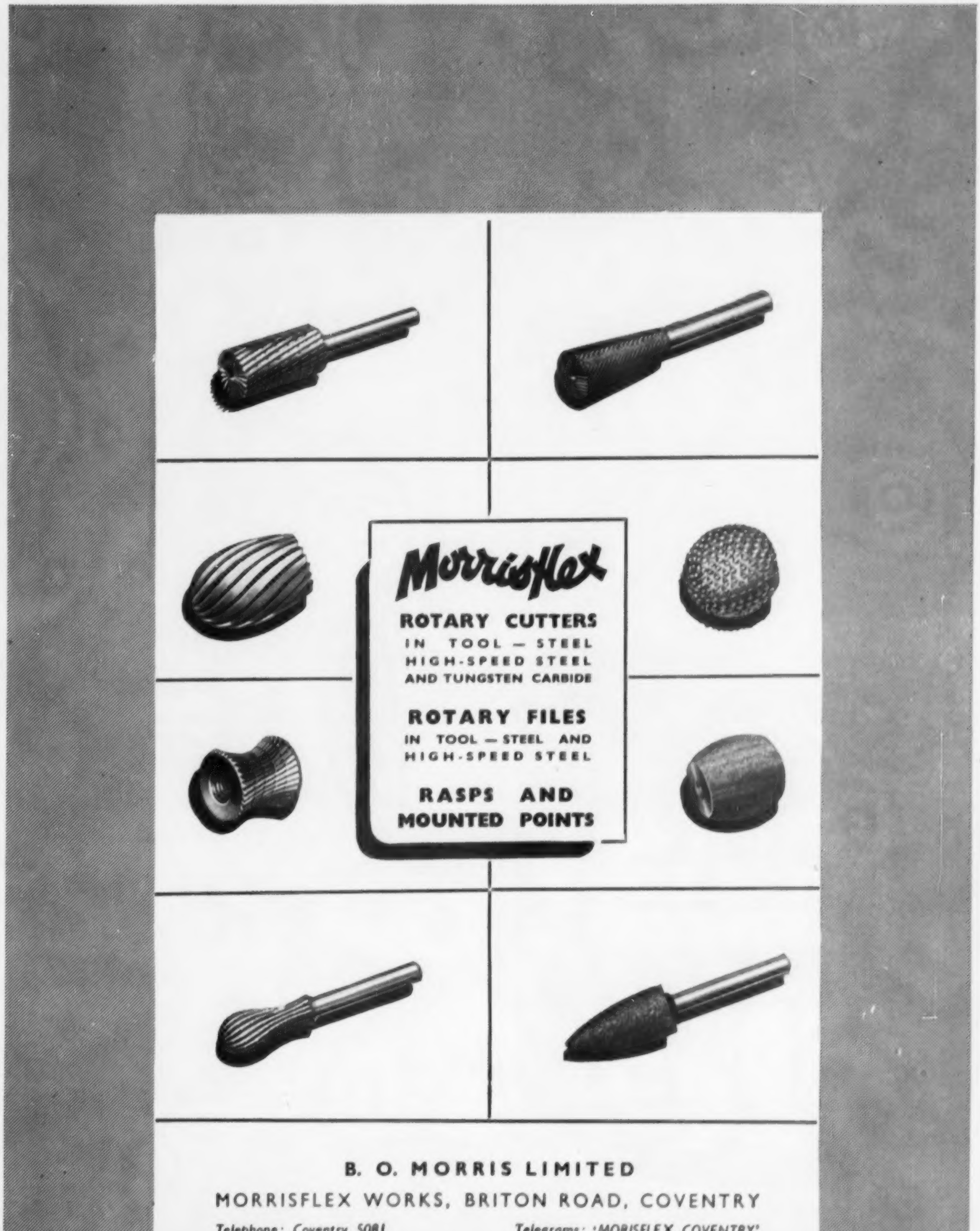
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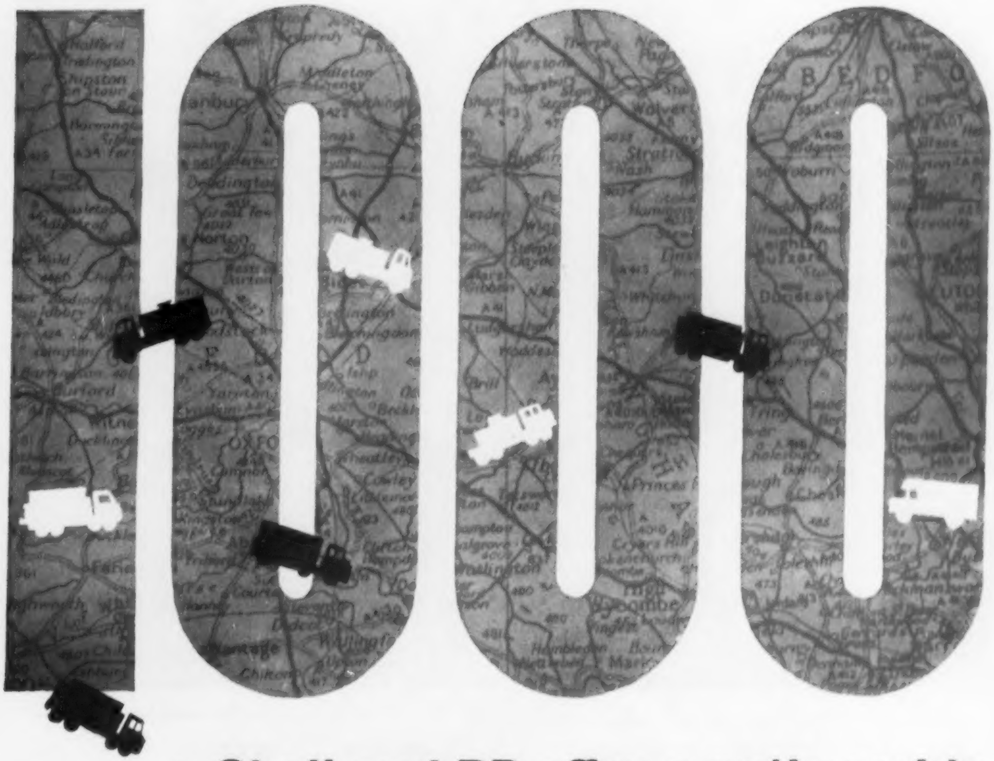

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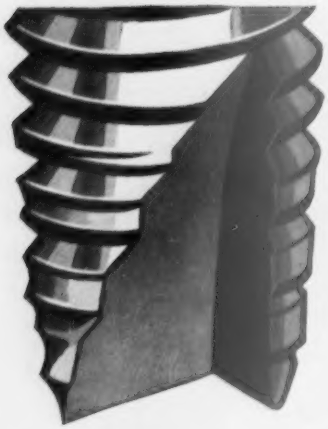

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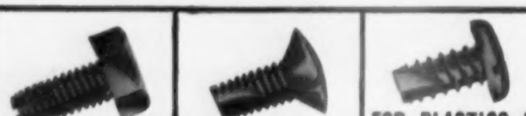

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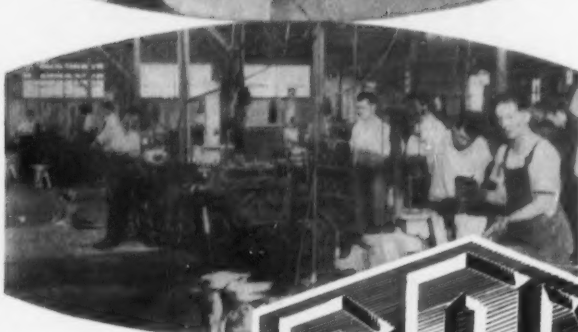

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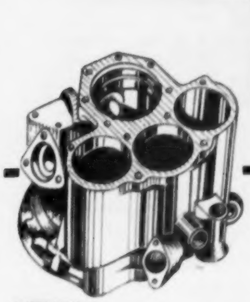

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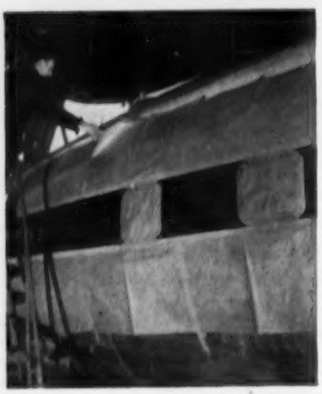

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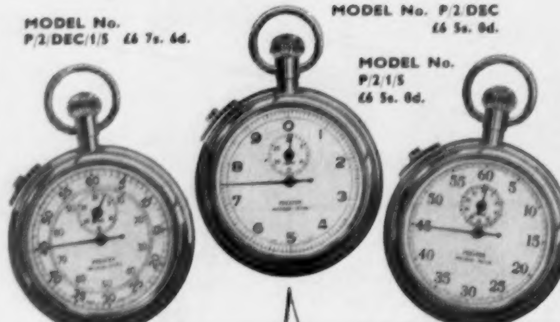

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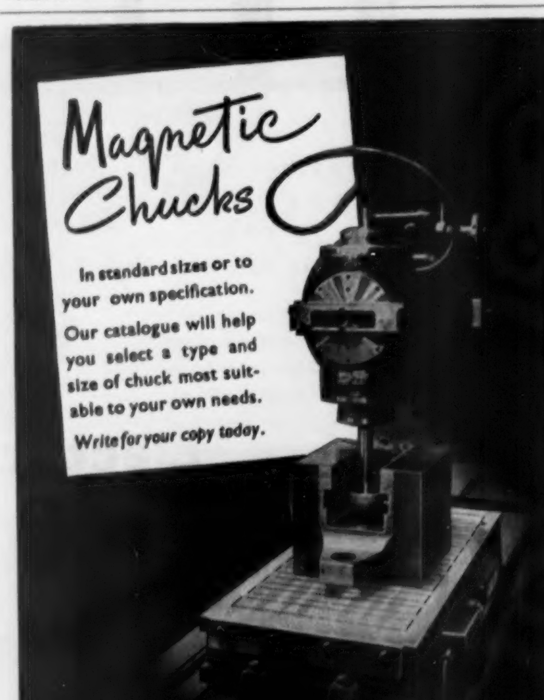

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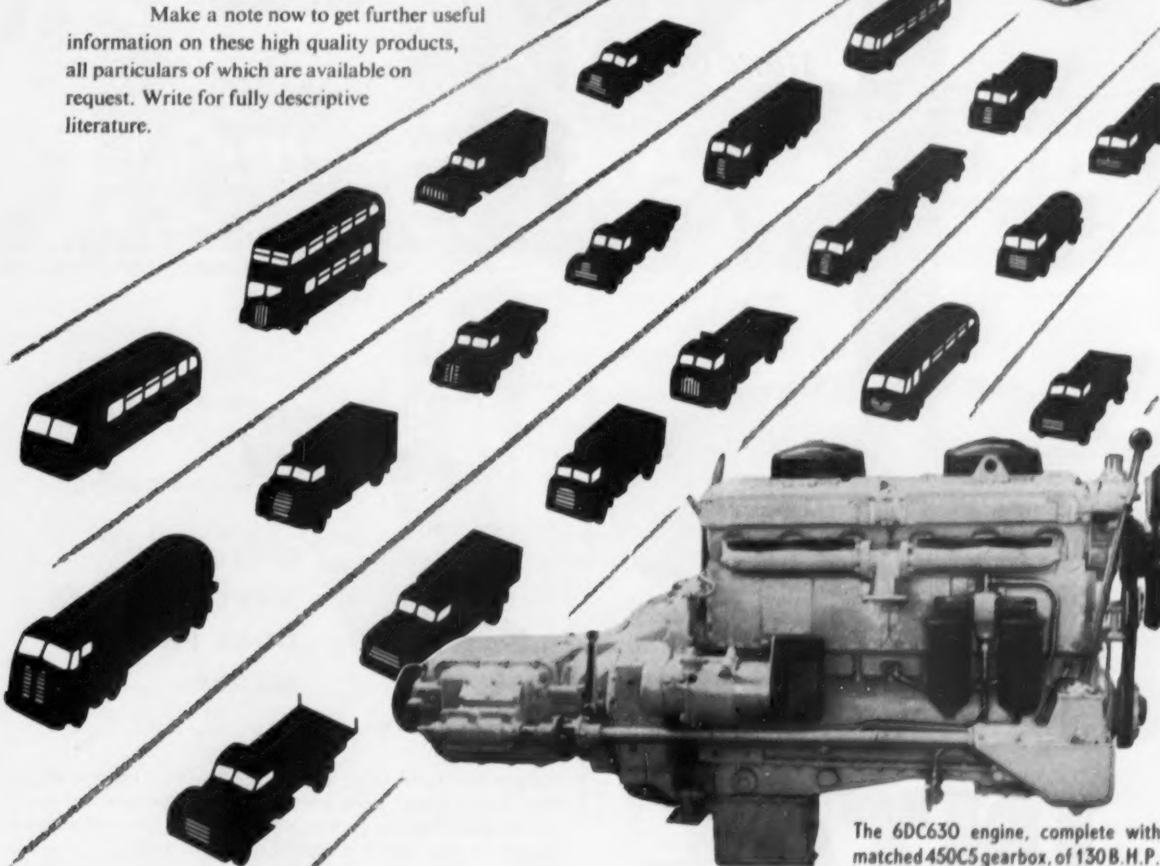

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Further particulars and application forms may be obtained from the Registrar, The University, Birmingham 15. Applicants are advised to apply before 1st August but applications received after this date may be considered if places are available.

G. L. BARNES,
Secretary

The University, Birmingham, 15.
April, 1956.

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APPLICATIONS are invited for pensionable posts as

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CANDIDATES must be between 21 and 28 years of age during 1956 (up to 31 for permanent members of the Experimental Officer Class) and have First or Second Class Honours degree in physics, chemistry, mechanical or electrical engineering, or mathematics. Candidates taking their degrees in 1956 may apply before the result of their degree examination is known.

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APPLICATION forms and further information from the Civil Service Commission, Scientific Branch, 30 Old Burlington Street, London, W.1. quoting number S 128/56. [5193

MINISTRY OF SUPPLY requires Workshop Officer at Doncaster to supervise operations at central depot for repair of vehicles (including petrol and C.I. engines) by contractors; to apply acceptance standards, etc. Qualifications: recognized engineering apprenticeship, preferably in motor industry. H.N.C. or equivalent desirable. Experience repair shop organization and reconditioning processes essential, also ability to drive and test critically all types civil and military wheeled vehicles. Salary: within £860-£1,070 p.a. Forms from M.L.N.S., Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting C 396/6A. [5194

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AGE at least 23 and under 35 years of age on 1st March, 1956, with extension for regular service in H.M. Forces and, up to two years, for established civil service. Candidates must (i) be corporate members of the Institution of Mechanical Engineers or (ii) have passed Sections A and B of the Institution's examinations for corporate membership or hold exempting qualifications, and have had practical experience in a position of responsibility in mechanical and/or automobile engineering.

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FURTHER particulars and application forms from Civil Service Commission, Scientific Branch, 30 Old Burlington Street, London, W.1, quoting No. S4595/56/9. Completed application forms should be returned by 23rd June, 1956. [5196

SITUATIONS VACANT

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AGE at least 25 and under 35 on 1st January, 1956, with extension for regular Forces' service and, up to two years, for established civil service.

CANDIDATES must be corporate members of the Institution of Mechanical Engineers, or have passed (or exempted from) the examinations necessary for corporate membership. Preference given to those who are members of the Automobile Division of the Institution. They must also have served an apprenticeship or have had postgraduate training in mechanical or automobile engineering and, in addition, had at least two years' practical experience on automobile engineering work.

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FURTHER particulars and application forms from Civil Service Commission, Scientific Branch, 30 Old Burlington Street, London, W.1, quoting No. S 4592/56/10. Completed applications should be returned by 21st June, 1956. [5197

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W. J. DEACON, Chief Education Officer. County Education Office, Trull Road, Taunton. [5186

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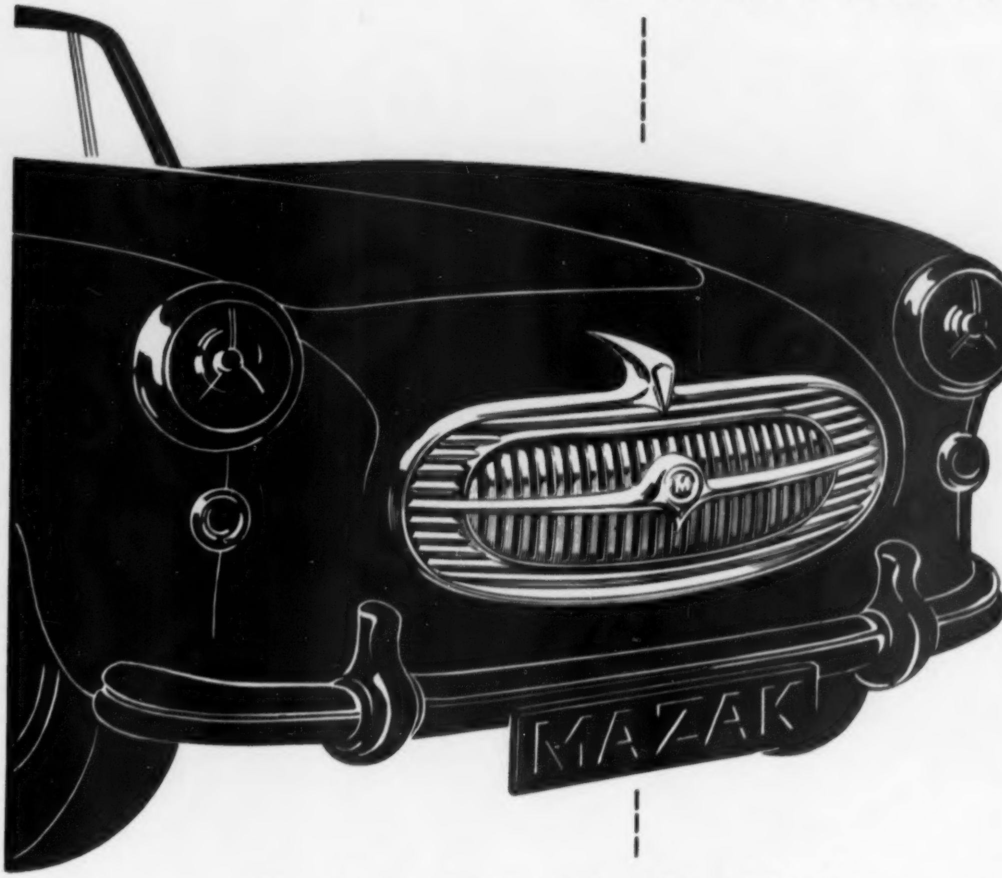

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